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REVISION OF THE PALÆOCRINOIDEA.

BY CHARLES WACHSMUTH AND FRANK SPRINGER.

PART III—SECTION II.

SUBORDER ARTICULATA.

The Articulata include the group formerly defined by us under the family name Ichthyocrinidæ, with the addition of *Crotalocrinus* and *Enallocrinus*, which possess in a remarkable degree some of the most characteristic features of the group. We have elsewhere shown that our former definition of the structure of the ventral surface in the Ichthyocrinidæ was faulty in the use of the word "soft," in which we did not have in mind the idea of membranous as opposed to calcareous, or of disk as opposed to vault, but simply employed the word to express more strongly the notion that the vault was not rigid. We maintain, however, that the outer test of the ventral side in this group was a continuous integument, composed of calcareous plates, united by ligament and not by a close suture, and that by reason of this structure and the articulation among the plates of the dorsal side it must have been pliant or flexible. The exact nature of this integument we do not know. The plates may have been arranged in various ways; they may even have been imbricated in some types—like the interambulacral plates in some Periechocrinidæ, and even in some of the true Echini—these are points we may perhaps never be able to settle. That there was an inner integument roofed in and covered by the flexible vault we have mentioned, and that it contained the summit plates and "covering pieces" we know to be true in the Crotalocrinidæ, and we think it altogether probable that the general plan of the ventral structure for the Articulata generally is expressed in that of *Crotalocrinus.*

The effect of the patelloid plates, observed in *Forbesiocrinus*, in permitting mobility in the whole skeleton, has been heretofore mentioned. The suggestions we then made are confirmed by the discovery of the remarkable articulation not only among the radials themselves, but also between the radials and interradials (Pl. 6, figs. 3–5). This articulate structure, and the consequent mobility in the test, and flexibility of the vault, we consider characteristic of the whole group, though it may vary in degree, and is probably far less perfect in some genera than in *Forbesiocrinus* and *Onychocrinus*.

Zittel (Handb. d. Palæont., i, p. 353–5–6), has separated the genera which belong to this suborder into three families, viz.: = Taxocrinidæ, including: (A), *Taxocrinus*, *Forbesiocrinus*, *Onychocrinus*, *Gissocrinus*, *Myelodactylus;* (B), *Lecythocrinus* (?), *Dactylocrinus* (*Dimerocrinus* Pictet); Ichthyocrinidæ, including: *Homalocrinus*, *Lecanocrinus*, *Clidochirus*, *Mespilocrinus*, *Ichthyocrinus*, *Anisocrinus* and *Pycnosaccus;* Crotalocrinidæ, including *Crotalocrinus*, *Enallocrinus*, *Cleiocrinus.* Angelin refers *Taxocrinus*, *Forbesiocrinus*, *Gissocrinus* and *Myelodactylus* to the Taxocrinidæ; *Ichthyocrinus* and *Pycnosaccus* to the Ichthyocrinidæ; *Crotalocrinus* to the Crotalocrinidæ and *Enallocrinus* to the Enallocrinidæ.

The so-called genus *Myelodactylus* may be left out of consideration. It was founded upon columns only, and, if correctly identified by Angelin, which is improbable, it would not belong to the Articulata at all. A separation of the genera included by us in the Ichthyocrinidæ into two families is desirable, but all attempts to define satisfactory characters for such families have so far failed. We have tried to arrange them according to Zittel's definition as well as various plans of our own, but without success, and we have come to the conclusion that the separation must be based upon characters as yet undetected. It is a remarkable and perplexing fact that in this whole group such characters as the presence or absence of interradials dorsally, the number of primary radials, or the position of the anal or azygous plate, whether resting on the basals or not, seem to be of little value.

Until some new light shall be obtained we see no other course than to leave the family Ichthyocrinidæ as we have already defined it.

Gissocrinus, which is placed by Angelin and Zittel among the Taxocrinidæ on account of having three underbasals, belongs to the Fistulata, and has been referred by us to the Cyathocrinidæ, as have also *Lecythocrinus* and *Dactylocrinus.* In addition to the genera formerly included by us, we refer *Cyrtidocrinus* to the Ichthyocrinidæ.

Cleiocrinus was independently referred by Zittel to the Crotalocrinidæ, and by us to the Ichthyocrinidæ. It differs from all other Articulata in the position of the interradials and may prove to be the type of a distinct family.

F. Roemer established the family Anthocrinidæ to receive *Anthocrinus* and *Crotalocrinus*, and Pictet, as Dujardin and Hupé, recognized the family Anthocrinidæ, but referred to it only *Anthocrinus*. As *Anthocrinus* proves to be a synonym, the family name will fall with it, and we shall distinguish the family as Crotalocrinidæ, and follow Zittel in referring to it *Crotalocrinus*, *Enallocrinus*, but not *Cleiocrinus*.

The Crotalocrinidæ are distinguished by the possession of a ventral tube or anal appendage, located ventrally near the periphery. In *Crotalocrinus* it consists of a tube composed of eight vertical rows of heavy quadrangular pieces. In *Enallocrinus* its form is unknown. The family differs from the Ichthyocrinidæ in a similar way as Platycrinidæ from Actinocrinidæ in that the higher radials are imperfectly developed.

The Articulata, therefore, fall into two families, which are defined as follows:

A. ICHTHYOCRINIDÆ. Base dicyclic. Underbasals unequal, proportionally very small, rarely visible externally. Basals generally small. Dorsal cup chiefly built up of radial plates of different orders, abutting laterally against each other or separated by interradials. Number of radials variable in genera, species and individuals. Radial and arm plates decreasing in size in the successive orders, each division being about half as wide as the preceding one, and of uniform size in corresponding divisions of the ray, but the plates of adjacent rays generally alternate with each other. The line of articulation between radials and arm plates is frequently undulating, and there are sometimes additional patelloid pieces. Arms uniserial, bifurcating, generally touching laterally so as to form a wall continuous with the calyx. Arm plates with straight sides and very deep ambulacral grooves. Pinnules apparently wanting.

Interradial system chiefly developed on the ventral side. Special anal plate sometimes resting on the basals, sometimes upon the radials, and sometimes wanting dorsally. Anus unknown in most of the genera. The radials are united longitudinally by articulation, laterally by ligament, the interradials among each other and with the radials by a loose suture, admitting of motion and producting flexibility in the calyx and vault.

B. CROTALOCRINIDÆ. Base dicyclic. Underbasals unequal, small. Basals generally large. Radials so far as known, 2×5. Arms uniserial, with numerous branches, spreading broadly. The branches of each ray partly or completely connected by lateral projections or direct union. When completely connected, they form reticulated leaves overlapping when folded. Pinnules wanting. Ambulacral furrow deep, ramifying with the arm branches, covered by alternating plates and bordered by side pieces. The first anal plate rests on the basals; it is followed by others which form the base of a ventral tube. Interradials numerous, covering the entire ventral surface, but not more than one or two—sometimes none—are exposed dorsally. Calyx roofed over by a pliant integument of irregular plates, extending over the arm bases, and enclosing the summit plates and covering pieces of the disk. Ventral tube lateral.

FAMILY XI.—ICHTHYOCRINIDÆ W. and Spr.

We are of the opinion that some of the genera described by Angelin are founded upon characters of specific value only, but as the original specimens are unique and inaccessible to us, we cannot, at present, undertake to review them.

ICHTHYOCRINUS Conrad, Rev. i, p. 33.

No new species of *Ichthyocrinus* have been described since our first list, in which, however, we omitted to notice *Ichthyocrinus arthriticus* (d'Orbigny), mentioned in Prodr. i, p. 46, which is a *Gissocrinus*, and also *Ichthyocrinus capillaris* and *I. goniodactylus* (d'Orbigny), which Phillips had correctly referred to *Cyathocrinus.*

HOMALOCRINUS Angl., Rev. i, p. 35.

ANISOCRINUS Angl., Rev. i, p. 37.

CALPIOCRINUS Angl., Rev. i, p. 38.

LECANOCRINUS Hall, Rev. i, p. 39.

1882. **L. Soyei** Oehlert. Bull. Soc. Géol. de France (ser. 3), vol. x, p. 354, Pl. 8, fig. 2. —Lower Devonian. Near Sabré, France.

Lecanocrinus elegans Billings, see **Taxocrinus elegans** Billings; **Lecanocrinus lævis, Taxocrinus lævis.**

CYRTIDOCRINUS Angl., Rev. i, p. 145.

Cyrtidocrinus was placed by us among the "imperfectly known genera," but should be referred to the Ichthyocrinidæ, as it is closely allied to *Lecanocrinus*, from which it differs only in having four in place of three underbasals. Like that genus it has a small, quadrangular azygous piece, placed obtusely against the posterior basal, and between it and the right postero-lateral radial. The upper radials are extremely narrow.

The only known species is *Cyrtidocrinus fascietatus* Angelin.

PYCNOSACCUS Angl., Rev. i, p. 41.

MESPILOCRINUS De Kon and Leh., Rev. i, p. 41.

TAXOCRINUS Phill., Rev. i, p. 43.

Additional species :—

*1884. **Taxocrinus Beyrichi** (Dewalque MS.) Fraipont, **Zeacrinus Beyrichi**; Extr. des Ann. de la Soc. Géol. de Belg., Tome xi, p. 112, Pl. 1, fig. 5.—Dev. superieur. Senzeille, France.

1882. **T. curtus** Williams, Proc. Acad. Nat. Sci. Phila., p. 30.—Portage group. Ithaca, N. Y.

*1856. **T. elegans** (Billings), **Lecanocrinus elegans** Rep. géol. Surv. Canada, p. 278; also 1859, Decade iv, p. 47, pl. 4, fig. 4 *a b*.—Trenton limest. City of Ottawa, Can. We consider this species, and also **Lecanocrinus lævis** E. Billings, to be **Taxocrinus.** They evidently possess no azygous plate, as they should have if they belonged to **Lecanocrinus.**

Taxocrinus Egertoni (**Poteriocrinus Egertoni** Phill. = **Cladocrinus Egertoni** Aust.), Rev. i, p. 48, is probably an **Onychocrinus** having 6–7 radials.

1882. **Taxocr. Fletcheri,** Bull. i, Illinois St. Mus. Nat. Hist., p. 31; also Geol. Rep. Illinois vii, p. 308, Pl. 30, fig. 2.—Kinderhook gr. Marshall Co., Iowa.

1882. **T. ithacensis** Williams, Proc. Acad. Nat. Sci. Phila., p. 29, Pl. 1, fig. 10.—Portage gr. Ithaca, N. Y.

*1856. **T. lævis** (E. Billings), **Lecanocrinus lævis,** Rep. Geol. Surv. Canada, p. 278; also 1859, Decade iv, p. 47, Pl. 4, fig. 3 *a*.—Trenton limestone. City of Ottawa, Can.

*1836. **T. nobilis** (Phill.), **Poteriocrinus nobilis** Geol. Yorkshire, p. 205, Pl. 3, fig. 40.—This species has been regarded by some authorities as identical with **Forbesiocrinus nobilis** De Kon. and Lehon; but is in our opinion not only specifically distinct, but in all probability a **Taxocrinus.**—Mountain limest. Bolland, Engl.

1852. **T. oligoptylus** (Pacht.).—**Dimerocrinus oligoptylus** Beitr., z. Kenntniss der Gattung **Dimerocrinus,** St. Petersburg, p. 8, with 3 plates.—Devonian. Costijitsi, Russia.

Syn. **Dimerocrinus aptilis** Pacht.

N. B.—*Taxocrinus priscus* (Schnur.) Steinninger, 1853, Geogr. Beschr. d. Eifel, p. 37, is not sufficiently defined for identification.

GNORIMOCRINUS W. and Sp., Rev. i, p. 50.

FORBESIOCRINUS De Koninck, Rev. i, p. 51.

Additional species :—

1859. **Forbesiocrinus Saffordi** Hall, Suppl. Geol. Rep. Iowa, p. 87.—Keokuk limestone. White's Creek, Tenn.
1879. **F. parvus** Wetherby, Jour. Cincin. Soc. Nat. Hist. (October number), p. 5, Pl. 11, figs. 4 *a b*.—Kaskaskia gr. Pulaski county, Ky.

N. B.—*Forbesiocrinus Whitfieldi* Hall, which has been referred to the genus *Taxocrinus*, according to Meek and Worthen (Geol. Rep. Illinois, vol. v, p. 553), came from the Kaskaskia group, of Randolph Co., Ill., and not from the Keokuk limestone, as stated by Hall. It also occurs at that horizon in Pulaski Co., Ky.

LITHOCRINUS W. and Sp., Rev. i, p. 52.

ONYCHOCRINUS W. and Sp., Rev. i, p. 53.

1882. **Onychocrinus distensus** Worthen, Bull. Ill. St. Mus. Nat. Hist, p. 31, also Geol. Rep. Ill., vii, p. 307, Pl. 29, fig. 5.—Kaskaski gr. Monroe Co., Ill. (We are unable to distinguish this specimen from *O. exsculptus* Lyon and Cass.)

NIPTEROCRINUS Wachsm., Rev. i, p. 55.

Zittel (Handb. der Pal., p. 352) refers this genus to the *Cyathocrinidæ*, probably on account of its three small underbasals. The presence of interradials clearly removes it from that family, and its waving sutures leave no doubt that it was properly placed by us among the *Ichthyocrinidæ*.

FAMILY XII.—CROTALOCRINIDÆ.

CROTALOCRINUS Austin.

1843. Austin, Ann. and Mag. Nat. Hist., Ser. I, vol. xi, p. 198.
1848. Morris, Cat. Brit. Foss., Ed. 1, p. 50.
1854. Salter, apud Murchison, Siluria, Ed. 2, p. 219.
1855. McCoy, Brit. Pal. Foss., p. 55.
1873. Salter, Cat. Mus. Cambr., p. 123.
1878. Angelin, Icon. Crin. Suec., p.26.
1879. Zittel, Handb. d. Pal., i, p. 356.
1882. De Loriol, Pal. d. France, tome 11, Crin., p. 51.
    Syn. *Anthocrinus*, 1853, Müller, Abhandl. Aka. Berlin, p. 192; 1857. Pictet Traite de Pal., iv, p. 312; 1862. Dujardin and Hupé, Hist. Nat. Zooph. Echin., p. 117; 1855. Quenstedt, Handb. d. Petref., iv, p. 943.

Crotalocrinus was established by Austin in 1843 (Ann. and Mag. Nat. Hist., p. 198), for the reception of a single species, which was described by J. S. Miller, in 1821, as *Cyathocrinus rugosus*, from a calyx without the arms. He had previously used the name *Crotalocrinites rugosus* (1842, Ann. and Mag., vol. x, p. 109), in his list of the class *Pinnastella*, and he referred it to the *Marsupiocrinoidea*. His original definition of the genus is as follows:

"Dorsocentral plates, 5; first series of perisomic plates, 5; second series, 5. On the latter are a series of wedge-shaped plates, which bear the rays; the exact number of these plates is unascertained. Column with a pentapetalous perforation."

"*C. rugosus.* The plates surrounding the body agree with the generic characters. Rays numerous, probably amounting to one hundred. Column composed of thin joints, articulating into each other by radiating striæ. The columnar canal is pentapetalous. The rays are remarkably small in proportion to the size of the animal."

McCoy, in 1854 (Brit. Pal. Foss., p. 54), redescribed the genus, but gave little additional information regarding it. He mentions the presence of an interradial plate in the "second perisomic row," and says that above, and alternating with the primary radials, are five large pentagonal secondary radials (scapulæ), completing the cup, on each of which rests a series of small pentagonal plates, supporting for the width of each plate a large number (? 15 or 16) of very slender long rays. According to McCoy, the genus "differs from *Cyathocrinus* in the vast number of its rays."

Hisinger (Leth. Suec. Supp., II, p. 6) described under the name *Cyathocrinus pulcher* a specimen without arms which afterwards proved to be of this genus.

Johannes Müller was the first to call attention to the remarkable characters of this type exhibited in the brachial parts. In 1853 (Abh. Ak. Wiss. Berlin, p. 187, *et seq.*), he described, under the head of "Crinoiden mit netzförmigen Händen," some specimens from Gothland in which the arm structure was well shown. He says he could not identify Hisinger's species because his figure was too imperfect, although he thinks it may have belonged to the same group. He also says that a specimen with arms and branches somewhat resembling the net-form had been obtained from Dudley, which he acknowledges to be *Cyathocrinus rugosus* Miller, but he expresses the opinion that the arms in the English form are not laterally connected and that it must have had more than five arms. Regarding, therefore, the English form as described by Miller, Austin and McCoy as distinct from the Gothland form with reticulated arms, Müller proposed for the latter the genus *Anthocrinus*, of which there was but a single species, *A. Lovêni.*

Angelin (Icon. Crin. Suec., p. 26), with the whole of the excellent material from Gothland before him, finds that *Anthocrinus Lovêni* is a synonym of Hisinger's *Cyathocrinus pulcher*, and that it belongs, along with *C. rugosus*, to Austin's genus *Crotalocrinus*, of which he also describes and figures a third species, *C. superbus.* According to his definition of the genus, there are five arms, connected at their bases by branches and pinnules, and the pinnules, reticulately connected by narrow transverse joints, form a broad plicated net. This reticulate structure, by which all the ramifications of each ray throughout their entire length are united into a net-work, seems to be the principal distinction between this genus and the closely allied *Enallocrinus*, in which the arm branches are transversely connected for a short distance near the base, but are free for the greater part of their length. Angelin uses the word "pinnules" carelessly, and it is evident that in this case it means simply the ultimate divisions of the arms. The character intended to be described by Angelin is much better stated by Zittel (Handb. d. Pal., i, p. 356), and Johannes Müller (1853, Berl. Akad., pp. 187–192).

Generic Diagnosis.—The calyx is constructed very similar to that of the Cyathocrinidæ. Its form is subglobose; its symmetry bilateral. With arms closed, the Crinoid resembles an elongated bud with folded leaves. With outspread arms its figure is that of a flattened disk with five deep, narrow, lanceolate areas, which separate the rays.

Base dicyclic. Underbasals 5, small, pentangular. Basals 5, large, hexagonal and octagonal. Primary radials 2×5; the first wider than high, excavated in the middle of the distal face for the reception of a very small trigonal, bifurcating second radial, upon which the arms originate and bifurcate in much the same manner as in *Marsupiocrinus.* The lateral margins of the first radials are very deeply incurved, extending between the arm bases until they meet the tegminal plates on the ventral side. The arms divide into numerous branches, which are connected throughout their entire length, in such a way that the brachial apparatus of the whole animal is included in five broad, net-like leaves with inrolled edges, which when closed overlap each other. These leaf-like arms are separated by very prominent, deep petaloid areas, whose margins are formed by the deeply incurved lateral faces of the peripheral arm joints, and the radials which are enormously thickened. When spread out, these connected rays would be free from contact with one another, and would resemble the outstretched leaves of a pentapetaloid flower, but folded together they overlap just as the closed leaves of a bud or flower. The arm joints are disposed in regular dichotomizing longitudinal rows, and also in regularly concentric transverse rows, the alternate arrangement of joints of adjacent branches being absent here. The arm branches are transversely compressed and flattened, very deep in proportion to their width, meeting throughout their entire length by their lateral surfaces.

Upon the dorsal side, the branches are laterally connected by points of attachment projecting from the middle of each point, or by direct contact of the sides of the joint, in such a way as to produce a reticulated structure composed of numerous small meshes. The projection of the points of attachment from the middle of the joints gives them the appearance, when seen from the dorsal side, of a cross with short arms, and the network appears to have regular cross-shaped meshes. At the lower part of the arms the joints are not cross-shaped, but meet directly by their sides, and the reticulate appearance is not so marked as higher up. The whole structure of these leaf-like rays is adapted to the greatest flexibility in all directions, and we think it probable that the meshes of the network were occupied by elastic connective substance of some kind. The joints are flat on the dorsal side; near the calyx they are extremely thick from the dorsal to the ventral side, the thickest being those which rest upon the radials, and they decrease rapidly toward the extremities of the rays. The articular faces at the ends of the joints are provided with an axial canal. Along the ventral side the joints are deeply excavated for the ambulacral furrow, which ramifies with the arm branches throughout their length. The furrow is lined at each side by a row of small side pieces, three to four to each arm joint, which inclose in the middle two rows of covering plates, alternately arranged, of equal number with the side pieces.

The dorsal cup is roofed over and covered by an integument of comparatively heavy interradial plates of irregular arrangement, which extend out some distance over the rays and enclose the bases of the arms, but in no sense constitute or include covering plates of the arms, as Angelin's figure (Pl. xxv, fig. 15) clearly shows. The plates at the margin of this integument meet and connect with the incurved edges of the radials and peripheral row of arm joints, which are proportionally much thicker than those of other parts of the ray. The arms, with their covering plates, which are laterally connected without the interposition of interradials or interaxillaries, emerge from underneath this integument, which must have been pliant to admit of the varieties of positions assumed. Also the summit plates—oral and proximals—must have been located beneath this integument, or we could not understand their position and relation to the covering pieces which are represented by Angelin's figure on Pl. xvii, fig. 3 *a*. Only occasionally the first interradial is visible dorsally; the dorsal cup, however, includes always a comparatively large subquadrangular anal plate, which rests between the radials and upon a hexagonal basal. This supports a very long, tapering, lateral ventral tube, which rises between the arms. It is composed of vertical rows of short, transverse pieces, and its walls are pierced by numerous pores.

The calyx plates appear to be united by syzygy, in part at least, and the lines of junction are marked by pits and clefts which penetrate deeply into the walls, as shown in fig. 4, Pl. viii, of Angelin.

Column heavy, round, composed of thin joints, whose articular faces are traversed by small radiating canals, which form pores on the external surface. Axial canal large, pentangular.

Geological Position, etc.—Upper Silurian of Gothland and England.

These species have been described:

1821. **Crotalocrinus rugosus** Miller, **Cyathocrinus rugosus** Nat. Hist. Crin., p. 89, pts. 1 A—4 B.—1808. Parkinson, **Turban** or **Shropshire Encrinite,** Org. Rem., Vol. ii, p. 193, Pl. 15, figs. 4, 5.—1837. Hisinger, **Cyathocrinus rugosus,** Leth. Suec., p. 89, Tab. xxv, fig. 3 *a*; also Antekni, Heft iv, p. 217, Tab. vii, fig. 3.—1839. Phillips, **Cyathocrinus rugosus** Phillips, apud Murchison's Sil. Syst., p. 672, Tab. 18, fig. 1.—1843. Austin, Ann. and Mag.

Nat. Hist., Ser. 1, Vol. xi, p. 198.—1843. Morris, Cat. Brit. Foss., Ed. 1, p. 50.—1850. D'Orbigny, **Cyathocrinus rugosus**, Prodr. d. Pal., Vol. i, p. 46. —1854. Salter, apud Murchison, Siluria, Ed. 2, p. 219, figs. 4–7, Tab. 13, fig. 3.—1855. McCoy, Br. Pal. Foss., p. 55.—1873. Salter, Cat. Mus. Cambr., p. 123.—1878. Angelin, Icon. Crin. Suec., p. 26, Tab. vii, fig. 4; Tab. xvii, figs. 3, 3 *a-b*, 8, 8 *a*.—1879. Zittel, Handb. d. Pal., i, p. 357, fig. 244.—1885. Quenstedt, Handb. d. Petref., iv, 942, Tab. 75, figs. 2, 3.—Upper Silurian. Gothland, Sweden, and Dudley, England.

1840. **C. pulcher** Hisinger, **Cyathocrinus pulcher**, Leth. Suec. Supp. ii, p. 6, Tab. xxxix, figs. 5 *a*, *b*.—1878. Angelin, Icon. Crin. Suec., p. 26, Tab. vii, figs. 5–7, 7 *a–b*; Tab. viii, figs. 1–9 *a*; Tab. xvii, figs. 1, 1 *a–d*; Tab. xxv, figs. 8–20.—1879. Zittel, Handb. d. Pal., i, p. 357, figs. 2, 4, 4 *a–d*. Syn., **Anthocrinus Loveni** Joh. Müller, 1853, Abh. d. Berl. Akad., p. 192, Tab. viii, figs. 1–11.—Pictet, 1857, Tr. d. Pal., iv, p. 312, Pl. c, fig. 8.—Dujardin & Hupé, Hist. Nat. Zooph. Echin., p. 117.—Quenstedt, 1885, Handb. d. Petref., iv, p. 943, Tab. 75, figs. 4, 5; Petref. Deutschl., iv, p. 508, Tab. 108, fig. 13.—Upper Silurian. Gothland, Sweden.

1878. **C. superbus** Angelin, Icon. Crin. Suec., p. 26, Tab. xvii, figs. 2, 2 *a–b*.—Upper Silurian. Gothland, Sweden.

ENALLOCRINUS d'Orbigny.

1850. D'Orbigny, Prodr. de Pal., Vol. i, p. 46; Cours Elem., ii, p. 142.
1854. Salter, apud Murchison, Siluria. Ed. 2, p. 218.
1857. Pictet, Traite de Pal., iv, p. 320.
1862. Dujardin and Hupé, Hist. Nat. Zooph. Echin., p. 134.
1878. Angelin, Icon. Crin. Suec., p. 25.
1879. Zittel, Handb. d. Pal., i, p. 356.
Syn., *Apiocrinites* (Hisinger) in part; *Millericrinus* (d'Orbigny) in part.

In 1850 d'Orbigny established this genus to receive two species, which had been noticed and figured by Hisinger as *Apiocrinus scriptus* and *A. punctatus*. Only the calyx was then known, and the generic definition simply stated that this was composed of five depressed basals, five large "subradials" and five "brachials." He placed the genus in the family Melocrinidæ, while Pictet, and also Dujardin and Hupé, referred it to the Cyathocrinidæ. Angelin makes it a distinct family, and Zittel considers it as belonging to the Crotalocrinidæ. It is clearly separated from the Inadunata by the fact that its radial divisions are connected either by direct union or by interradial plates between the secondary radials. Although Angelin, in his definition of the genus (Icon. Crin. Suec., p. 25), states "interradialia nulla," his figures demonstrate their undoubted presence both on the dorsal and ventral side (Pl. xv, figs. 1*a*, 3*a*; Pl. xxv, figs. 4, 4*a*). It appears from these illustrations that in some cases the corresponding radials of adjacent rays meet again above the interradials, just as in some species of *Ichthyocrinus* and *Batocrinus.*

The genus differs from *Crotalocrinus*, its nearest ally, in the absence of the reticulate arm structure, although there is a lateral connection between the arm branches for some distance above their bases; also in the alternate arrangement of adjacent rows of arm joints. The construction of the ventral covering is apparently the same in both forms. There is, however, a difference in the mode of union of the calyx plates, the lines of junction in *Enallocrinus*, showing strong indications of an articulation, as we judge from Angelin's figs. 1, 4, and 4 *a*, of Pl. xxv. Angelin united the two types of Hisinger under his first species *E. scriptus*, and described one new species.

Generic Diagnosis.—The calyx differs but little from that of *Crotalocrinus*, and when the arms are spread this produces a similar discoid figure, and lanceolate areas similar to those of that genus. The calyx is depressed, broadly expanding, composed of thick plates with deeply beveled sutures, indicating a union by articulation. Base dicyclic; symmetry bilateral; underbasals 5, depressed, linear; basals 5, large, hexagonal, angular above, except on the anal side; radials 2×5, the first one wide, with its distal face occupied by a deep lunate excavation, which is filled by the second radial and the two first arm joints. Lateral faces of first radials deeply incurved between the arm bases, and meeting tegminal plates on the ventral side. Second radial trigonal or pentagonal, and on its superior sloping margins the arms bifurcate as in *Marsupiocrinus.* The first arm-joint small, linear, sometimes coalesced with the second; the second small, axillary; arms broad, thick, composed of short uniserial joints, dichotomizing frequently. The branches are laterally connected near their bases, but throughout the greater portion of their length are free. Arm joints alternating with those of adjacent rows. As in *Crotalocrinus*, the outer sides of the peripheral rows of the rays are the thickest, and the deep inward curvature of their exterior lateral faces leaves similar large petaloid or lanceolate areas. The exterior ventral margins of the incurved radials of the first and higher orders, and some of the lower arm joints, connect with the plates of the ventral covering, which is of a similar nature as that of *Crotalocrinus.* Ambulacral furrow deep, dichotomizing with the arm branches, bordered by two rows of small alternating side pieces, and covered along the median line by two rows of saumplättchen.

Anal plate one, in line with first radials. Of the numerous interradials only one or two are exposed dorsally, and these are succeeded ventrally by an indefinite number of other vault plates. Ventral tube lateral, its construction unknown. Column strong, round, with short joints; axial canal large, round or obtusely pentangular.

Geological Position, etc.—Upper Silurian; known only from Gothland, Sweden.

Two species have been recognized:

1828. **Enallocrinus scriptus** Hisinger (**Cyathocrinites?**), Anteckn iv, p. 217; Tab. v, fig. 9; Tab. vii, fig. 1.—1831. (**Apiocrinites** (?) **scriptus**), Anteckn v, p. 123, Esquisse d. tab. petrif. d. Swede, p. 23.—1837. Leth. Suec., p. 89, Tab. xxv, figs. 1 and 2.—D'Orbigny, 1840 (**Millericrinus scriptus**), Hist. Nat. Crin., p. 94, Pl. xvi, fig. 29.—1850. Prodr. d. Pal. i, p. 46.—Angelin, 1878, Icon. Crin. Suec,, p. 25, Tab. vii, figs. 1–3 a; Tab. ix, figs. 18 and 19; Tab. xxv, figs. 1–7; Tab. xxvii, figs. 17–20 a.—Upper Silurian. Gothland, Sweden.

Syn.—**Enallocrinus punctatus** Hisinger, Leth. Suec., p. 89.—**Millericrinus punctatus** d'Orbigny, Hist. Nat. Crin., p. 94, Pl. xvi, fig. 30.—**Enallocrinus punctatus** Salter, apud Murchison, Siluria, Ed. 2, p. 218.—**Anthocrinus scriptus** and **A. punctatus**, Quenstedt, Handb. d. Petref. iv, p. 944, Tab. 75, figs. 6, 7.

1878. **E. assulosus** Angelin, Icon. Crin. Suec., p. 26, Tab. xv, figs. 1–4.—Upper Silurian. Gothland, Sweden.

CLEIOCRINUS Billings.

1856. Geol. Surv. Canada, p. 276.
1859. Ibid, Decade IV, p. 52.
1879. Wachsm. and Spr., Rev. i, p. 35.
1879. Zittel, Handb. d. Pal., i. 357.

Cleiocrinus in its general habitus has close affinities with the *Ichthyocrinidæ* and *Crotalocrinidæ*, and this has induced us to place it provisionally with the Articulata, without assigning it to any special family, although it differs in two important points. *Cleiocrinus*, contrary to all other Articulata, has an interradial in lateral contact with the first radials, forming a ring with them, and the plates of the calyx apparently were not articulated in a strict sense. Zittel has referred the genus to the *Crotalocrinidæ*, while we placed it in Part I with the *Ichthyocrinidæ*. If certain parts were better known, we should make it the type of a new family, but at present, having no positive knowledge of the basal regions, nor even of the arms, we are not in a position to give a satisfactory definition of the group.

In order to obtain some additional information, we applied to our friend, Walter R. Billings, who, with his usual kindness, has furnished us the diagrammatic sketch of the type-specimen, which is reproduced on Plate 9, fig. 5. The suture lines of all plates above the primary radials, vertically and horizontally, are provided with a kind of minute pores; which, it seems to us, indicates a union by syzygy, and not by articulation, and that the arm structure was altogether different from that of the other Articulata. Mr. Billings informs us that "the plates are all joined together, but where the strain in crushing has acted upon the specimen, the cracks or gaping sutures are preferably on the lines of the grand divisions, *i. e.*, the lines dividing the arms from one another and from the anal series." This parting of the plates, however, does not indicate necessarily a leaf-like structure of the rays, as in the case of *Crotalocrinus*, for all plates united by syzygy, as a rule, come easily apart.

Mr. Billings informs us that the ridges of the column are interradial in position, which confirms the supposition made by us (Part I, p. 36), that *Cleiocrinus* possesses underbasals, and that the so-called basals of E. Billings are interradials. He also states that the lowest visible circlet of plates "apparently overlaps the column, instead of passing under it," which shows that the base must have been concave, with ample space for the basals and underbasals to lie concealed from view. We have indicated the basals and underbasals in the diagram by dotted lines.

It will be useful to give an amended—

General Diagnosis.—General form obconical; with bilateral symmetry. Base dicyclic. Underbasals probably 3, minute or rudimentary. Basals probably 5, small and hidden by the column. Primary radials 3 × 5, increasing in width upwards, supporting several superior orders of radials, dichotomizing frequently and uniformly, and interlocking with those of adjoining rows.

The rays and their divisions are laterally connected, without the intervention of interradial plates, except at the anal side and along the first primary radials. The first radials are much smaller than the succeeding ones, and separated from one another by a comparatively large pentangular interradial. The interradial of the posterior side is quadrangular, and supports a longitudinal row of anal plates, which extend to the full length of the calyx, and in their form closely resemble the radials. Arms apparently recumbent. Column more or less obtusely pentagonal; axial canal large.

Geological Position, etc.—Lower Silurian, Canada. No additional species have been described.

SUBORDER INADUNATA.

a. Branch, Larviformia.

The Larviformia comprise the families: *Haplocrinidæ*, *Symbathocrinidæ*, *Cupressocrinidæ* and *Gasterocomidæ*.

The Haplocrinidæ are the simplest brachiate Crinoids and may be regarded as representing the larva, not only of the Inadunata but of the Palæocrinoidea generally. Even the most complicated Platycrinoid or Actinocrinoid must have passed in its early life a stage in which radials and interradials consisted of but a single ring of plates when we think the interradials covered the entire ventral surface. This stage is probably represented by the young *Allagecrinus*. In *Haplocrinus* the conditions are essentially the same, but here the interradials already began partly to open out, and the oral plate made its appearance upon the surface. It is very possible that also the growing *Allagecrinus* before reaching maturity attained this condition, or perhaps even the condition of *Symbathocrinus*, but in default of any such evidence, we refer the genus for the present to the Haplocrinidæ.

The Haplocrinidæ are very closely allied to the Symbathocrinidæ, and it is a question with us, whether it would not be better to unite them under one family. Both are built essentially on the same plan, but the Symbathocrinidæ—at least their typical genus—had proximals, and, as a rule, a somewhat higher developed mode of articulation. The articular facet in the Symbathocrinidæ forms a straight horizontal line, it is extended into a large muscle-plate, and this covers the greater part of the ventral cavity, leaving only a small median space, which is covered either by the interradials and an oral plate as probably in *Pisocrinus*, or by interradials and a full set of summit plates as in the case of *Symbathocrinus*. In the Haplocrinidæ the interradials[1] are comparatively large, and rest upon the upper face of the main part of the radials; in *Symbathocrinus* small, placed against the distal ends of their limbs, and separated by radial dome plates. In the Haplocrinidæ the anal opening penetrates one of the interradials, and also probably in *Pisocrinus*, *Storthingocrinus* and *Stylocrinus;* in *Symbathocrinus* and *Phimocrinus* it is placed along the suture of two adjacent muscle-plates. This position of the anal opening between the muscle-plates is a peculiarity found exclusively among the Larviformia; we meet with it again in Cupressocrinidæ, and in a somewhat different form among Gasterocomidæ.

The Cupressocrinidæ and Gasterocomidæ are dicyclic Crinoids, containing within their basal ring an undivided plate in form of a disk. The disk is pierced by several large openings, a central one which represents the axial canal, and by four (exceptionally three or five) peripheral ones, which are continued to the whole length of the column. The other two families have only a central opening, which is small. Dr. P. H. Carpenter, whom we consulted as to the functions of these openings, thinks it " very probable that the peripheral ones represent downward extensions of the body cavity in which water circulated; while there was an exhalant or outgoing current through the interradial (so-called anal) opening with which the intestine was related, so that fæcal matter could be carried away from the creature, very much as it is by the circulation through the dorsal and ventral siphons of a *Solen* or *Mya.*"

The specimens for which Hall (1862, 15th Rep. N. Y. St. Cab. Nat. Hist.) proposed the name *Ancyrocrinus* are evidently crinoidal stems with four peripheral canals, and as such may belong to *Myrthillocrinus* or some other genus of this family. There are at the lower end four lateral appendages, which in our opinion are a kind of radicular cirrhi. In a specimen from the Canada Survey Museum of Ottawa we found the lower face of the stem covered by a calcareous deposit closing the canals. This deposit appears to have been of a similar nature to that which closes the centro-dorsal of Comatula and the nodal stem joints of the Pentacrini, which, according to Wyville Thomson and Carpenter (Chall. Rep., pp. 18, 19), occasionally break their stems at a syzygy so as to become free. In the case of *Ancyrocrinus*, however, the stem may have become detached and the free state been the rule in the adult, as those stems with their anchor attached are found in great abundance.

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[1] If the five ventral plates in *Haplocrinus* and the allied *Allagecrinus* were orals, as Dr. P. H. Carpenter suggests, it would follow that these two genera exceptionally had no interradials, and vary on this point from all other Palæocrinoidea. To this we had reference on p. 72, but in place of stating, as we intended, "Carpenter denies the interradials to be present *always* in Palæocrinoids," we made the erroneous statement: "C. denies that interradials are present *as a rule* in Palæozoic Crinoids." The correction was made throughout our own edition, but we discovered the error too late to rectify it in the Proceedings of the Philadelphia Academy.

The bottom plate in the calyx of the *Cupressocrinidæ* and *Gasterocomidæ*, which we take to be a coalesced underbasal disk, has been described heretofore as representing the upper joint of the column, because the plate, at least in the adult, is undivided. It is, however, well known that a fusion of one or more plates takes place not only among basals, but also among underbasals; while, on the other hand, the columnar joints, which in most of the *Crinoidea* are undivided, sometimes are tri- and quinquepartite. The plate of *Cupressocrinus* unquestionably has the position of the united underbasals; it forms, like them, a part of the calyx, as much so as the basals of *Dolatocrinus* and *Stereocrinus*, in which, as a general rule, the sutures are totally obliterated, and in which the basal disk resembles most remarkably the underbasal disk in this family. It is to be regretted that neither the central canal nor the angles of the column in *Cupressocrinus* give any light on this question, the former being circular, the column quadrangular; but it seems to us that the plate, if really representing a stem-joint, should be quadrangular, in accordance with the other stem-joints in this genus, and not pentangular, as we always find it.

The muscle-plates of the *Cupressocrinidæ* have a more horizontal position than in the *Symbathocrinidæ*, and those of different rays are laterally anchylosed, so as to form an annular plate with a central opening. There is, besides, an interradial lateral opening, and five pairs of radial ones. The central space was probably covered by interradial and summit plates, but these occupied a comparatively small space of the ventral surface, the larger portion being covered by the muscle-plates. The interradial opening represents the anus, the outer radial ones the axial canals, the inner and larger ones are probably ambulacral openings.

The arms of the *Gasterocomidæ* have similar axial canals as those of the *Cupressocrinidæ*, but these face outward, while the others are directed upward. This is readily explained by the condition of their articular facets, which are lateral, horseshoe-shaped, and do not extend over the whole width of the plates. The articular facets of the radials throughout this family, instead of bending over to the ventral side, stand erect as in *Platycrinus*, and their outer ends support the interradials in a similar manner as in that genus. In accordance with this structure, it is evident that, if the anal opening was to occupy a position corresponding to that of *Symbathocrinus* and *Cupressocrinus*, it had to be located, as it is throughout this group, dorsally between the upper portions of the radials, which resemble structurally, if not quite functionally, the extensions of the muscle-plates in the other groups. The radials of the *Gasterocomidæ* have limb-like extensions, they are simply notched for the ambulacral canal, and their axial opening penetrates the median portions of the plates.

The *Larviformia* agree with the Blastoids as to certain conditions of their arm structure (see our notes on *Cupressocrinus*), and probably possessed hydrospires and hydrospire pores to connect with the ambulacra; *Cupressocrinus* even had similar pinnules. The arms are simple throughout, but some of the radials, exceptionally, support two arms. The arms were united with the radials by strong muscles; but the arm-plates among each other, so far as known, were suturally connected and moved in a body.

We give the following definitions of the four families :—

A. HAPLOCRINIDÆ. Dorsal cup small, composed of basals and radials; covered ventrally by five large single interradial plates, which form a pyramid. These plates are supported upon the outer ends of two adjoining radials, and are united with one another, leaving only a small ambulacral opening. There is no anal plate; the anal aperture, so far as known, penetrates the upper part of one of the interradials. Column with small central canal.

B. SYMBATHOCRINIDÆ. Dorsal cup small; composed of basals and radials only. The latter are provided with large muscle-plates, which are connected by suture, except at their inner ends, where they leave generally a slit-shaped opening. The muscle-plates extend over the greater part of the ventral surface, and constitute a more or less elevated pyramid, with an open space in the centre. The central space is closed by comparatively small interradials and the summit plates; the latter, as a rule, are more extensively developed than in the *Haplocrinidæ.* The arms are extremely long, closely folded together. They are composed of quadrangular joints, suturally connected, and moved upon the radials by means of strong muscles. The anal opening, where it has been observed, is intermediate between two muscle-plates. Column round, with a small central canal.

C. CUPRESSOCRINIDÆ. Calyx large. Base dicyclic. The underbasals are anchylosed, and form a solid disk, which is succeeded by five basals. The radials are provided with large muscle-plates, which are laterally anchylosed, and form a continuous plate covering a large portion of the body. It stands on a level with the upper faces of the radials, and is pierced by the anus and the ambulacral openings. The arms are simple, closely folded together, and composed of massive, wide, quadrangular pieces, which, being connected by suture, moved in a body upon the radials. Column strong, containing a large central canal surrounded by peripheral ones.

D. GASTEROCOMIDÆ. Base dicyclic; basals and underbasals as in the Cupressocrinidæ. Radials large; their articular facet lateral, horseshoe-shaped, covering almost the whole outer face of the plates. They are provided with large axial openings, which occupy the median portions of the facets, and are notched at their upper end to pass in the ambulacral canal. The anal opening is dorsal, placed between two radials, and either succeeds the anal plate, or this succeeds the opening. The interradial plates are small occupying the equatorial zone. The oral plate is very large, excentric, and surrounded by four large proximals, its posterior side resting against the radials. Arms recumbent or widely divergent.

FAMILY XIII.—HAPLOCRINIDÆ.

Under this family we place only the two genera *Haplocrinus* and *Allagecrinus.* Roemer referred to it *Haplocrinus* and *Coccocrinus*, in which he was followed by Zittel and S. A. Miller. Schultze, like us, referred *Coccocrinus* to the Platycrinidæ, but added *Triacrinus*, which Zittel, Angelin and Miller made the type of a distinct family. We admit there are close affinities between *Haplocrinus*, *Triacrinus* and *Pisocrinus*, but we believe the last two are closer allied to *Symbathocrinus* (see our notes on the Symbathocrinidæ). Pictet refers to the Haplocrinidæ: *Haplocrinus*, *Coccocrinus*, *Myrtillocrinus*, *Ceramocrinus*, *Epactocrinus* and *Gasterocoma;* Dujardin and Hupé: *Haplocrinus*, *Coccocrinus*, *Myrtillocrinus* and *Stephanocrinus*. D'Orbigny arranged his "Aplocrinidæ" between the Pentremitidæ and Cupressocrinidæ.

In Troost's catalogue of 1850 we find the following names: *Haplocrinus granulatus*, *H. hemisphericus*, *H. maximus* and *H. ovalis*, which have not been defined, and are species of *Pisocrinus* and *Triacrinus*. *Haplocrinus annularis* and *H. monile* were defined by Eichwald from pieces of the column.

HAPLOCRINUS Steininger.

(Pl. 5, figs. 1, 2.)

1834. Steininger, Bull. Soc. géol. de France (Ser. i), vol. viii, p. 231.
1844. F. Roemer, Rhein. Uebergangsgebirge, p. 63.
1849. Steininger, Versteinerungen der Eifel, p. 20.
1853. Steininger, Geognostische Beschr. d. Eifel, p. 36.
1852. Quenstedt, Handb. d. Petrefactenkunde, p. 624.
1855. J. Müller, Verh. naturh. Verein, Jahrg. xii, p. 21.
1855. F. Roemer, Lethaea Geogn. 1855 (Ausg. 3), p. 260.
1857. Pictet, Traité de Paleont., iv, p. 308.
1862. Dujardin & Hupé, Hist. natur. des Zoophytes Echin., p. 105.
1862. Hall, 15th Rep. N. Y. St. Cab. Nat. Hist., p. 143.
1866. Schultze, Echin. Eifel Kalk., p. 103.
1868. De Koninck, Bull. d. l'Acad. Roy. d. Belg. (Ser. 2), Tome iii (Extr. p. 63).
1879. Zittel, Handb. d. Palæont., i, p. 347.
1882. Quenstedt, Handb. d. Petrefactenkunde (Ausg. 3), p. 964.
1885. P. H. Carpenter, Chall. Rep. Crinoidea, p. 158, etc.
Syn. *Eugeniacrinites* Goldfuss (in part), 1826, Petref. Germ. i, p. 213.
Syn. *Aplocrinus* d'Orbigny, Prodr. i, p. 102.
Syn. (?) *Dimorphocrinus* d'Orbigny (Zittel).

The first species of this genus was described by Goldfuss under *Eugeniacrinites mespiliformis*. Goldfuss did not know the construction of the plates, nor did Steininger who described the same species under *Haplocrinus spaeroideus*. F. Roemer, in 1844, gave a good description of the plates, but his way of interpreting them was rather peculiar. According to his diagnosis, the calyx of *Haplocrinus* is composed of five basals. These, as he states, alternate with five "para-basals," of which three are separated from the basals by intervening plates (Costalglieder). He states further that, placed upon the sutures of two adjoining "para-basals," there are five simple arms, which in their closed condition form a pentamerous "Scheitelpyramide." If it were true that the latter plates, which at their lateral union form conspicuous grooves, were arms, this Crinoid would have no radials, and the basals would be radially disposed, contrary to the fundamental rules of the class. The ventral pyramid had been erroneously described by Goldfuss as composed of five series of eight to ten pieces longitudinally arranged, and it was this, likely, which misled Roemer. The fact, however, is that the ventral surface is covered by five single trigonal pieces, arranged alternately with the upper ring of plates in the dorsal cup, and that the latter plates, as Goldfuss correctly stated, are provided with an articular facet upon which the arms moved. This was confirmed by Müller's observation, who, in 1855, discovered in one of his specimens, resting upon the facet, a small brachial.

Allman was the first writer who undertook to homologize the five ventral plates of *Haplocrinus*, *Coccocrinus* and *Stephanocrinus* with the orals of recent Crinoids. It seems, however, that he was not aware of Müller's discovery of arm joints, for he supposed that all those genera possessed recumbent ambulacra. A similar view was held by d'Orbigny. Schultze calls the ventral plates "interradiale Pyramidenstücke." Zittel describes the "Kelchdecke" to be composed of "fünf grossen, im Centrum zusammenstossenden, dreieckigen Oral-platten, welche eine Pyramide bilden, und zwischen sich fünf breite, gerade, durch die abgeschrägten Seitenflächen begrenzte, nach unten geschlossene, nach oben offene Ambulacralfurchen bilden." There is nothing to confirm this view, and, in fact, we do not know how this could have been possible. It is difficult to see what office the so-called "open ambulacral groove" could have had, especially if *Haplocrinus* possessed arms, as Prof. Zittel admits. The grooves, evidently, are mere compartments for the reception of the arms, and served for their protection. Carpenter agrees with Zittel that the ventral plates are orals, but opposes his open ambulacra. He regards the genus to be "permanently in the condition of a Pentacrinoid larva with a closed tentacular vestibule." We fully agree with him that *Haplocrinus* is a persistent larval form, but do not understand how the five large plates, which occupy almost the entire ventral surface, and as much as one-half of the whole test, possibly can represent the orals in a Palæocrinoid, as all other genera of this group in which the ventral covering has been observed, have largely developed interradials, and these, whether composed of one or a series of plates, extend up invariably to a comparatively small area surrounding the peristome. We, therefore, regard the small central piece as the homologue of the orals, and not the five large plates which we take to be interradials.

The basals of *Haplocrinus* were described by Dujardin and Hupé to be composed of three pieces in place of five. The three small plates alternating with the basals, the "Costalglieder" of Roemer, which are radial in position and support three of the arm-bearing plates, were called by Schultze "parabasalia," by De Koninck "subradials," while Müller, Pictet and Zittel called them "first radial plates." The term parabasals was used by Schultze for basals in dicyclic Crinoids, and, therefore, cannot be applied to radial plates, neither can the name "subradials," as also this term has been used in the same sense. We regard the three plates as representing mere sections of the radials, which, jointly with the arm-bearing part above, are equivalent to one of the undivided radials of the other two rays.

Generic Diagnosis.—Of very small size. Form of calyx subglobose, sometimes biturbinate, extending almost over the whole ventral surface. The summit pieces are represented only by a small oral plate.

Basals five, small, pentagonal, forming a shallow cup with slightly acute angles. Radials very irregular, two of them consisting of single pieces, the other three of two plates each, connected by suture. The two single plates, which agree in size—but not in form—with the compound ones, belong to the anterior ray and left postero-lateral one; they are heptagonal and almost of the same form and size. The three compound ones differ from one another; two of the lower segments are pentagonal, that of the right anterior ray hexagonal, its left lateral face being angular. The upper segments are quadrangular, except the one of the right postero-lateral ray, of which the lower corner is slightly truncated. The articular faces form a straight line, and occupy about one-third the width of the radials. They enter deeply the upper surface of the plates, and form at each side of them a rather conspicuous upright projection, which is truncated at the upper face. These projections are laterally connected in pairs, and each pair supports a large interradial plate, which almost covers the whole ventral surface. The five interradials join with one another; they are subtrigonal, their angles truncated; the upper angle so as to admit a small oral plate, the other two to make space for the articular facet. The sides of the plates along their suture line are beveled, thereby producing along the suture line, in a radial direction, a deep groove, which, evidently, was occupied by the arms in their closed condition. Beneath these grooves there is an opening in the test, at which the ambulacra enter the calyx. The openings contain along their median line the ambulacral passage, which is oval in form. At each side of it there is apparently another opening, which Schultze described as "kleine grubenartige Vertiefungen," whose functions we cannot understand unless they are in connection with the respiratory apparatus. There is no anal plate; the anal opening is small, and penetrates the upper part of the interradials close to the oral plate.

The arms are imperfectly known, but they probably were long, simple, and composed of long joints, like those of the Larviformia generally. The articulation upon the radials was by muscles, the axial canals being plainly visible. Column cylindrical.

Geological Position, etc.—*Haplocrinus* seems to have had a wide vertical range, three species being from the Devonian, the fourth one, according to De Koninck, from the Carboniferous (?).

The following species have been described :—

1862. **Haplocrinus clio** Hall, 15th Rep. N. York State Cab. Nat. Hist., p. 143, Pl. 1, figs. 5–9.—Marcellus Shale. Onondago Co., N. Y.

1868. **H. granatum** De Koninck, Bull. d. l'Acad. Roy. de Belg. (Ser. 2), Tome iii, No. 4, Pl. 5, figs. 6–10.—(?) Mountain limest. Bolland, Yorksh., England.

1826. **H. mespiliformis** (Goldfuss), **Eugeniacrinites mespiliformis**, Petref. Germ., i, p. 213, Pl. 64, fig. 6.—**Haplocrinus spæroideus**, 1834, Steininger, Bull. Soc. Geol. de France, Tome viii, p. 232.—**Haplocrinus mespiliformis** F. Roemer, 1844, Rhein. Uebergangsgeb., p. 16; also Leth. Geogn., 1855 (Ausg. 3), p. 261.—Pictet, 1857, Traité de Paléont., iv, Pl. c, fig. 2.—Bronn, 1860, Klassen d. Thierreichs (Actinozoa), Pl. 28, fig. 4 A–C.—Dujardin and Hupé, 1862, Hist. Nat. des Zoophytes Echinod., p. 105, Pl. 5, fig. 9.—Schultze, 1866, Echin. Eifl. Kalk., p. 104, Pl. 12, figs. 10, 11.—Devonian. Eifel, Germany.

1844. **H. stellaris** Roemer, Rhein. Uebergangsgeb., p. 63, Pl. 3, fig. 5; also Sandberger, Jahrbuch, 1845, p. 777.—Roemer, 1855, Lethæa Geogn. (Ausg. 3), p. 261.—Devonian. Nassau, Germany.

ALLAGECRINUS Ether. & Carp.

1881. Ann. and Mag. Nat. Hist. (April), pp. 281–298.
1884. De Loriol, Paléont. Francaise (Serie i), Tome xi, p. 46.

Allagecrinus was made by Etheridge and Carpenter the type of a distinct family, and this was accepted by De Loriol. In our opinion it is either a Haplocrinoid or no Palæocrinoid at all. If the five ventral plates, as E. and C. assert, are orals, which in the younger specimens extended to the radials, closing in the tentacular vestibule, but in their subsequent stages were "relatively carried inwards, away from the radials, and separated from them by perisome," we should regard *Allagecrinus* a Neocrinoid. If, however, it is a Palæocrinoid, we think the five ventral plates are interradials, which in the young Crinoid were closed, and gradually opened out so as to expose the summit plates. In this case, *Allagecrinus* was in its earlier life morphologically in a similar condition as *Haplocrinus*, but may have attained in the adult a somewhat higher degree of development.

Messrs. Etheridge and Carpenter state on p. 284 of their paper on *Allagecrinus*, that the mouth in the larger specimens could not have been " roofed over or closed by a dome or vault of any kind," for " if such a structure had existed within the circle of radial plates, it would assuredly have been preserved." To this we reply, that the summit structure of *Symbathocrinus* which is comparatively solid was discovered after hundreds of the most perfect specimens had been examined, and until then it was regarded as membranous; the same was the case in *Cyathocrinus*. *Allagecrinus* in its more advanced stages, may have attained the conditions of *Haplocrinus* or *Symbathocrinus*, or even of *Cyathocrinus*, and passed perhaps through all those phases successively; but there is not the least evidence that the Scheitelplatten in any Palæocrinoid were carried inward by perisome as in the Neocrinoidea.

The same writers remark on p. 286, that " in none of the smaller specimens is there any trace of an anal opening, either directly piercing an oral plate, or at the margin of the dome between the orals and radials." And they state further, that " the central end of one or more of the former may be marked by tubercles, but we cannot suggest any explanation of these." If E. and C. had regarded these tubercles as mere ornamentations, they certainly would have stated so. We judge from their figs.

5 and 7 *b*, on Pl. xvi, that one of the tubercles was larger than the others. The larger one may have been pierced by the anal opening, for it occupies relatively the same position as the anal opening in *Haplocrinus.*

We cannot agree with Etheridge and Carpenter that *Poteriocrinus isacobus* Austin, which we referred (Rev. I, p. 113) to *Scaphiocrinus*, is an *Allagecrinus.* The little cup, which Austin figured on Pl. 8, fig. 4, of his Monograph, is evidently a ring of underbasals, with a few stem-joints attached to it, and not basals. To judge from the figures, there is in our mind scarcely a doubt that, in some way or another, the calyx in the type-specimen became detached, that the basals and radials were lost, and the underbasals temporarily fastened to the arms for safe-keeping. Similar detached cups are frequently found in the Burlington limestone, and we doubt if there will ever be found a species of *Allagecrinus* with branching arms.

Generic Diagnosis.—Crinoid minute. Calyx pyriform or cylindro-conical. The dorsal cup composed of two rings of five plates each; the ventral surface, so far as known, of five single pieces. There are no anal plates, neither dorsally nor ventrally.

Basals five; suture-lines rarely visible. Radials five, elongate, variable in form and size; they are either axillaries and support two simple arms, or truncate above and bear a single arm, but neither one of them is branching; when axillaries, they are considerably wider. The articular facets for the attachment of the arms are large and distinct, and nearly horizontal in position, so as to give a projecting lip-like appearance to the upper and outer edges of the radials. There is a transverse articular ridge around the opening of the central canal, which is large. The arms are strong, cylindrical, and probably without pinnules. The first arm-joint is much shorter than the others, cuboidal, with a nearly circular distal face, the succeeding ones elongate, three and four times as wide as high.

The construction of the ventral surface is only known in the younger specimens, in which it consists of five interradial plates, which form a closed pyramid, the relative size of which is greater the smaller the specimen. The plates are trigonal, but the lower angles slightly truncate to form the arm-opening. In the smaller specimens, the plates are so closely united, that there is no trace of sutures between them; but the sutures gradually become more marked, and turn in the larger ones into rather distinct grooves. No central plate has been observed as in *Haplocrinus*, and nothing is known of the ventral surface in any of the larger specimens. Column short, of vermiform appearance; composed of small, low, rounded joints, with a circular central canal.

Geological Position, etc.—Restricted, so far as known, to the top of the Carboniferous limestone of Scotland and America.

1881. **Allageorinus Austini** Ether. and Carp. Type of the genus. Ann. and Mag., vol. vii, p. 289, Pts. 15 and 16.—Upper Carboniferous limestone of Scotland.
1882. **A. Carpenteri** Wachsm., Bull. I, State Mus. Nat. Hist., p. 40; also Geol. Rep. Illinois, vol. vii, p. 341, Pl. 29, fig. 14.—Kaskaskia group. Monroe Co., Ill.

FAMILY XIV.—SYMBATHOCRINIDÆ, W. and Sp.

We refer to this family the genera: *Symbathocrinus*, *Phimocrinus*, *Stylocrinus*, *Stortingocrinus*, *Pisocrinus*, *Triacrinus* and *Lageniocrinus*. Zittel made of these genera two families; he placed *Symbathocrinus*, *Phimocrinus* and *Lageniocrinus*, to which he added *Cupressocrinus*, under the "*Cupressocrinidæ*," and *Pisocrinus*, *Triacrinus*, with *Catillocrinus*, under the "*Pisocrinidæ*." These groups were adopted by De Loriol and S. A. Miller. We willingly admit that *Cupressocrinus* agrees with *Symbathocrinus* and *Phimocrinus* very closely in the mode of articulation and in the arm structure; but they differ essentially in other points. *Cupressocrinus* has a large dorsal cup, basals and underbasals, and three or four large peripheral canals, which follow the column. Nothing of this has been found either in *Symbathocrinus* or *Phimocrinus*, which both have a very small dorsal cup, and a small central opening along the column. After separating *Cupressocrinus*, and making *Symbathocrinus* the type of the group, it is extremely difficult to establish family distinctions between *Symbathocrinus* and Zittel's *Pisocrinidæ*. Not even the irregularity in the construction of the calyx will hold good, as also in *Symbathocrinus* the symmetry is disturbed by the presence of an anal plate. *Catillocrinus*, which also had been identified with these groups, has a ventral sac, and has been referred by us to the *Fistulata*.

SYMBATHOCRINUS Phillips.

(Pl. 4, figs. 8 to 11, and Pl. 5, figs. 12 to 14.)

1836. Phillips, Geol. Yorksh., Pt. ii, p. 206.
1843. Austin (in part), Monogr. Rec. and Foss. Crin., p. 93.
1850. D'Orbigny, Prodrome de Paléont., i, p. 156.
1852. Owen and Shumard, Geol. Surv. Ia., Wisc. and Minns., p. 597.
1854. McCoy, Syn. Brit. Palæoz. Foss.
1858. Hall, Geol. Rep. Iowa, Vol. i, Pt. ii, p. 559.
1868. Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 324.
1873. Meek and Worthen, Geol. Rep. Ill., Vol. v, pp. 324 and 437.
1875. Meek and Worthen, Geol. Rep. Ill., Vol. vi, p. 514.
1879. Zittel, Handb. d. Palæontologie, i, p. 349.
1880. Wetherby, Journ. Cincin. Soc. Nat. Hist. (Extr., p. 7).
Not *Symbathocrinus* Roemer 1855, Müller 1855, Schultze 1866 = *Stylocrinus* Sandberger.

The genus *Symbathocrinus*, as it is now recognized, contains two distinct generic types. The one which occurs in the Carboniferous and *upper* Devonian has a large anal plate, and this supports a long tube which extends to nearly the whole length of the arms. The other form, which is restricted to the *lower* Devonian, has no anal plate, nor does it show an anal opening. The Carboniferous form will be recognized by us as *Symbathocrinus*, the other as *Stylocrinus.*

When Phillips proposed the name *Symbathocrinus* he gave no description, he only stated that the " pelvis " was " anchylosed." The two Austins described Phillips' species, but they also took the base to be undivided, and nothing was said by them about an anal plate, although they indicated it in one of their figures (Monograph, Pl. 12, fig. 4 *b*). Their fig. 4 *a* is a totally different thing, and represents either a *Graphiocrinus* or *Scytalocrinus.* Owen and Shumard discovered the base of *Symbathocrinus* to be tripartite, and Prof. Hall was the first to describe the anal plate. The muscle-plate was taken by Zittel, and formerly by us, for a so-called consolidating apparatus, like the similar structure in *Cupressocrinus*, and homologous with the oral plates. It was also the general belief that the central space was not closed, and represented the mouth.

Symbathocrinus granulatus and *S. Tennesseæ* Troost are catalogue names, *S. tabulatus* (Goldfuss) a *Scytalocrinus*, and *S. tennesseensis* Roemer a *Pisocrinus.*

Generic Diagnosis.—Calyx small. Dorsal cup obconical or basin-shaped. Basals three, forming a shallow cup, which is slightly excavated for the reception of the column. They are composed of two larger equal pieces which are pentangular, and a smaller quadrangular one; the latter placed to the left of the anterior interradius as in *Platycrinus.*

Radials nearly equal, subquadrangular; the basi-radial suture slightly angular; width much wider above than below. Their upper side forms a straight, horizontal line, except at the right postero-lateral radial, of which the left upper end is sloped off for the reception of an anal piece. The anal plate rests completely upon this one radial, occupying about one-fourth of its upper width. The radials are provided with large articular facets, which, extending inwards and upwards, form jointly at the ventral side of the calyx a sharply angular pyramid with re-entering angles. The upper end of this pyramid is truncated, and contains a good-sized opening in the centre, which in perfect specimens is completely covered by the interradial and summit plates. The lateral margins of the facets meet at their lower ends, except at the azygous side, where they are separated by the anal plate; along their upper ends, however, they stand apart, and form rather conspicuous clefts. Each facet is divided vertically by a narrow sinus,[1] and the two halves of the plates or the limbs, as they might be called, at their upper end form an ambulacral opening.

The interradials are unusually small, wider than high; those at the four regular sides resting against the upper face of two limbs of adjoining radials. The number of interradials at the azygous side cannot be ascertained in our specimens, as the parts connecting the anal plate with the ventral surface of the calyx were not preserved. The anal plate stands in line with the first brachial, it has the same height but not its width, and is succeeded by a slender tube which follows the whole length of the arms. Hall has figured a second anal plate, triangular in form; this, however, constitutes the lower portion of the first plate of the tube, which always takes a sharp inward turn, leaving only a small triangular space exposed externally between the arms. The tube is composed of five rows of quadrangular, rather delicate plates, which are bent longitudinally so as to form an angle, and each plate extends to, and forms a part of, two of its sides. The interradials alternate with radial dome plates, which are even smaller, angular above.

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[1] These sinuses, which look somewhat like suture lines, give to the muscle plates the appearance of representing separate pieces, interradially disposed, and this led us at first to regard them as oral plates.

The summit is closed by the proximals and oral plate, all of which are much larger than the interradials. The proximals consist of four comparatively large, nodose plates, which enclose toward the azygous side three scarcely convex, smaller ones. The oral plate is the largest piece of the ventral side, it forms an inverted cup, containing radiating grooves along the inner floor, which lodged the ambulacra.

Arms five, long, simple; closely folded together and forming a narrow, cylindrical body. They are composed of a large number of quadrangular joints, with parallel sutures, and are provided with a deep ventral furrow, but apparently have no pinnules. The first brachial differs somewhat in form from the others; it is always higher, extending to the level of the oral plate; also wider, but not quite as deep. Its proximal face is provided with a muscular appendage, which corresponds with that of the radials; its distal end, however, shows neither ridge nor fossæ. The higher brachials in all probability were united by suture, and the arms moved as a body upon the radials. The articular faces of the latter are provided near their outer margin with a transverse ridge (Pl. 5, figs. 12, 13), extending to the whole width of the plate, with a transverse axial canal. The ventral furrow is deep, has a longitudinal groove along the inner floor, and rib-like projections alternating with grooves along the inner walls. The sides of the furrow are lined by two rows of short transverse side-pieces—about eight to each side of the arm joint—alternately arranged, which leave a zigzag median opening along the whole length of the arms. There are also lateral pores, one to every side-piece, and these connect with, and form the upper end of, the lateral furrows at the inner walls of the arm grooves to which we alluded. The lateral faces of the arm joints are provided along their outer side with shallow slanting grooves (Pl. 5, figs. 12, 13), and these agree in number with the pores. It seems to us very probable that, by means of these grooves, the ventral furrow was brought in contact with the surrounding element, as the arms in this genus are so closely folded together, that without them no communication was possible.

Column long, cylindrical; with small central canal.

Geological Position, etc.—*Symbathocrinus*, commenced in the Hamilton group, attained its greatest abundance in the two Burlington formations, and disappeared at the termination of the Keokuk period.

1869. **Symbathocrinus brevis** Meek & Worthen, Proceed. Acad. Nat. Sci. Phila., p. 68; also Geol. Rep. Illinois, vol. v, p. 439, Pl. ii, fig. 6.—Lower Burlington limestone, Burlington, Iowa.

1836. **S. conicus** Phillips, Geol. Yorkshire, p. 206, Pl. 4, figs. 12, 13; Austin, Ann. and Mag. Nat. Hist., x, p. 108; also Monog. Rec. and Foss. Crin., p. 93, Pl. 11, figs. 5 *b*, *c* (not 5 *a*, which is a Poteriocrinoid); d'Orbigny, 1850, Prodr. i, p. 156; McCoy, 1854, Syn. Brit. Palæoz. Foss., p. 118.—Mountain limest., Ireland and England.

1852. **S. dentatus** Owen & Shum., Jour. Acad. Nat. Sci. Phila. (new ser.), vol. ii, p. 93, Pl. 11, fig. 7; also 1852, Geol. Rep. Iowa, Wisc. and Minnesota, p. 597, Pl. 5 *B*, figs. 7 *a b*.—Upper Burlington limest., Burlington, Iowa.

1880. **S. granuliferus** Wetherby, Journ. Cincin. Soc. Nat. Hist., Pl. 16, figs. 3, 3 *a*.—Kinderhook gr., Kentucky.

1858. **S. matutinus** Hall, Geol. Rep. Iowa, vol. i, p. 483, Pl. i, fig. 2.—Hamilton gr., New Buffalo, Iowa.

1860. **S. Oweni** Hall, 13th Rep. N. York St. Cab. Nat. Hist., p. 111.—Kinderhook gr., Rockford, Indiana.

1861. **S. papillatus** Hall, Descr. New Crin. (Prelim. Notice), p. 18.—Upper Burlington limestone, Burlington (a mere variety of **S. dentatus**).

1865. **S. robustus** Shumard, Trans. Acad. Nat. Sci. Phila., vol. ii (Palæozoic Foss. America), p. 397.—Meek and Worthen, 1885, Geol. Rep. Illinois, vii, p. 514, Pl. 29, fig. 4.—Keokuk limestone. Button-Mould Knob, Ky., and Sulphur Springs, near Nashville, Tenn.

1858. **S. Swallovi** Hall, Geol. Rep. Iowa, vol. i, Pt. II, p. 672, Pl. 17, figs. 8 and 9.—(?) St. Louis limestone. Missouri.

1869. **S. Wachsmuthi** Meek and Worthen (not 1866 = **Catillocrinus Wachsmuthi**), Proc. Acad. Nat. Sci. Phila., p. 67; also Geol. Rep. Illinois, v, p. 437, Pl. 2, fig. 5.—Lower Burlington limestone. Burlington, Iowa.

1859. **S. Wortheni** Hall, Geol. Rep. Iowa, vol. i, Pt. ii, p. 560, Pl. 9, fig. 9.—Upper Burlington limestone. Burlington, Iowa.

PHIMOCRINUS Schultze.

1866. Schultze, Monogr. Echin. Eifl. Kalk., p. 29.
1879. Zittel, Handb. d. Palæontologie, i, p. 350.
1882. Oehlert, Bull. Soc. Géol. de France, Ser. 3, x, p. 353.

Phimocrinus agrees almost completely with *Symbathocrinus*, but it has *five* basals in place of three. It also has similar articular facets, which, in a like manner, form a stelliform pyramid, of which, however, the summit plates have not been observed. The anal opening is situated between two muscle-plates, and evidently was extended into a tube, as in *Symbathocrinus*. The form of the arms is not known. Column pentagonal, with a small pentalobate central canal.

Geological Position, etc.—*Phimocrinus* is restricted to the lower part of the Devonian.

1882. **Phimocrinus Jouberti** Oehlert, Bull. de la Soc. Géol. de France, Ser. 3, tome x, p. 352, Pl. 8, fig. 1.—Devonian. Sabré, France.

1866. **Ph. lævis,** Schultze (Type of the genus), Monogr. Echin. Eifl. Kalk., p. 29, Pl. 3, fig. 6.—Devonian. Eifel, Germany.

1866. **Ph. quinquangularis** Schultze, Monogr. Echin. Eifl. Kalk., p. 30, Pl. 3, fig. 7. —Devonian. Eifel, Germany.

STYLOCRINUS Sandberger.

(Re-defined by W. and Sp.)

1850. Versteinerungen Nassau's, p. 400.

Syn. *Platycrinus* (partim) Goldfuss, 1838. Nova Acta Leop. XIX, i, p. 345; also Quenstedt, 1852, Handb. d. Petrefactenk., Ed. 1, p. 618.

Syn. *Symbathocrinus* (partim) Müller, 1855, Verh. naturh. Verein für Rheinlande, xii, p. 19; also Neue Echin. Eifl. Kalk., p. 257; Schultze, 1866, Monogr. Eifl. Kalk., p. 26; Zittel, 1879, Handb. d. Palæont., i, p. 349.

Stylocrinus has been generally regarded as identical with *Symbathocrinus*, and Sandberger, when he proposed the name, failed to point out the generic differences. He applied the name to a species from Vilmar, which afterwards was found to be specifically identical with "*Symbathocrinus*" *tabulatus*, from the Eifel. The absence of an anal plate, and even of an anal opening in the Eifel species, was overlooked or disregarded by all European writers. Zittel described the ventral side of *Symbathocrinus* as plated, and containing an anal tube reaching to the tips of the arms; he also spoke of oral plates, which were said to form beneath the vault a concealed consolidating apparatus. This description, incorrect as it is, was evidently made from the Carboniferous form, as in the Eifel species nothing is known of the calyx beyond the radials. In *Symbathocrinus* the anal opening is located between two of the muscle-plates; but in the Eifel species, which we make the type of *Stylocrinus*, the muscular appendages of all the radials are suturally united. This suggests that the opening probably penetrated the interradials, as in *Haplocrinus*, and it may have had, like that genus, only an oral plate and no proximals.

In the construction of the dorsal cup, *Stylocrinus* agrees with *Symbathocrinus.* The two genera, however, differ in the articular extensions of their radials, which extend only inward, not upward, and form a level with the outer edges of the radials. The arms are composed of quadrangular joints, with parallel sutures, and they possess a deep ventral furrow. The column is circular, and consists of thick joints, those at the upper end being comparatively strong, but they are reduced very soon to less than one half of their greatest width.

The only known species is :—

*1838. **Stylocrinus tabulatus** (Goldf.), **Platycrinus tabulatus,** Nova Acta. Leopold. xix, i, p. 345. Quenstedt, Handb. d. Petrefactenk. (Ed. 1), p. 618, Pl. 54, fig. 25.—**Symbathocrinus tabulatus,** Müller, 1855, Verh. naturh. Verein f. Rheinl. xii, p. 19, Pl. 4, figs. 4, 5; Schultze, 1866, Monogr. Eifl. Kalk., p. 27, Pl. 3, figs. 4, 5.—Devonian. Eifel, Germany.

Var. alta Müller, Verein f. Rheinl. xii, Pl. 4, fig. 5; Schultze Monogr., Pl. 3, fig. 4.

Var. depressa Müller, ibid., Pl. 4, fig. 4; Schultze, ibid., Pl. 3, fig. 5.

Syn. **Platycrinus lævigatus** Goldf.; **P. alutaceus, P. scrobiculatus, P. nodulosus.**—These names were applied by Goldfuss to specimens in the Museum of Bonn to mere variations of **Stylocrinus tabulatus,** but have never been published (Schultze).

Syn. **Stylocrinus scaber** Sandberger, Versteinerungen Nassau's, p. 400, Pl. 35, fig. 12.

Syn. **Platycrinus gerolsteiniensis** Steininger, Geogn. Beschreib. d. Eifel, p. 37.

STORTINGOCRINUS Schultze.

1866. Monogr. Echin. Eifl. Kalk., p. 69.
Syn. *Platycrinus* (partim), Goldfuss and Wirthgen and Zeiler.

Stortingocrinus agrees in the lower portions of its calyx with *Platycrinus*, to which it was referred by Goldfuss and Müller. That it does not belong to the Camarata, and hence is no Platycrinoid, is shown by the mode of articulation, which is like that of *Haplocrinus*, and by the form of the radials, which, in the place of being notched, are extended upward, and support upon their limbs a single interradial as those of the Blastoids.

Generic Diagnosis.—Basals three, unequal; two of them twice the size of the third one, which is rhomboidal. Radials large, subquadrangular; their articular facets deeply inserted, forming a depression with a slightly concave upper face. Their lateral margins of adjoining radials are connected by suture, they extend upwards and inwards, forming partitions between the arm bases, leaving but a small space for the reception of the arms.

Column round, with a stellate central canal, its angles directed radially.

Geological Position, etc. *Stortingocrinus* is restricted, so far as known, to the lower beds of the Devonian of Europe.

*1838. **Stortingocrinus decagonus** (Goldfuss) **Platycrinus decagonus**, Nova Acta Ac. Leopold. xix, i, p. 345.—Schultze, **Platycrinus** (**Stortingocrinus**) **decagonus**; Monogr. Echin. Eifl. Kalk., p. 70, Pl. 10.—Devonian. Eifel, Germany.

*1855. **St. fritillus**, (Wirthgen and Zeiler), Type of the genus. **Platycrinus fritillus**, Verh. naturh. Verein f. Rheinl., Jahrg. xii (n. ser.), p. 80, Pl. 10, figs. 4 and 5.—Schultze, **Platycrinus** (**Stortingocrinus**) **fritillus**, Mon. Echin. Eifl. Kalk., p. 69, Pl. 10, figs. 8–8 f.—Devonian. Eifel, Germany.

Syn. **Platycrinus asper**, **P. pusillus**, **P. rugosus**, **P. scobiculatus** and **P. scaber** Goldfuss, and **P. minutus** Schurr.

*1866. **St. trifidus** (Schultze), **Platycr.** (**Stortingocr.**) **trifidus**, Monogr. Echin. Eifl. Kalk., p. 70, Pl. 10, figs. 8 a–g.—Devonian. Eifel, Germany.

PISOCRINUS De Koninck.

1858. De Koninck. Bull. de l'Acad. Roy. de Belgique (Ser. 2), iv, p. 104.
1873. Salter, Cat. Cambr. Museum, p. 128.
1879. Handb. d. Palæontologie i, p. 348.
1878. Angelin, Iconogr. Crin. Suec., p. 20.
1879. S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (July).

Syn. *Symbathocrinus* (in part), F. Roemer, Silur. Fauna, West Tenn., p. 55.

Syn. (?) *Triacrinus*, Münster, 1839 (in part), Beiträge zur Petrefactenkunde, p. 4.

Syn. *Symbathocrinus* (in part), Roemer, 1860, Silur., Fauna West. Tennessee, p. 55.

Pisocrinus is closely allied to *Triacrinus*, but the latter is said to have three basals; *Pisocrinus* has five. The arrangement of the other calyx plates is identical, and also the arm structure. Schultze, who observed in the Eifel species only three basals, postulated from this that the Silurian species from Sweden, for which De Koninck had established the genus *Pisocrinus*, also consisted of but three plates. Angelin, who succeeded Schultze, and who had at his command the extensive collections of the Stockholm Museum, describes the genus with five basals, and all his figures show five plates. We also examined from the same horizon in America several hundred specimens of at least three species from Western Tennessee, all of which have five basals and not three; but in one of those species the basals are so small that they were almost completely covered by the column, and it appears as if the sutures between the plates of the second ring, of which only three touch the basals, were the sutures between the plates of the first ring. A similar structure is found in *Pisocrinus pilula* (Iconogr., Pl. 4, fig. 4 *b*), a species which in its general aspect is closely allied to *Triacrinus depressus* Müller. We do not pretend to say, however, that this species had five basals; it is very possible that two of these plates became anchylosed, and that the genus made its reappearance in the Devonian with only three basals.

Generic Diagnosis.—Calyx in its general aspect clove-shaped, its form subconical, sometimes pyriform.

Basals five, unequal; three of them larger and trapezoidal, the two smaller ones trigonal, which combined form an irregularly triangular cup.

The radials are extremely irregular, only the two antero-lateral ones touching the basals. These two are more than twice as large as the other three plates; they are hexagonal, and have the same form and size. The anterior radial is triangular, with convex sides, and rests with its lower angle half way between the two larger ones. At the posterior side, the basals do not support a radial, but are succeeded by a pentangular azygous plate, which shares with the two large radials an equal part. The plate has the form of an axillary, is broadly truncate below, with short lateral faces, and is sharply angular above. The two postero-lateral radials meet above the azygous plate, resting upon its sloping upper sides, and against the upper half of the two larger radials. Their width is identical with that of the larger ones, and in a ventral aspect the radials appear to be perfectly symmetrical.

Pisocrinus has similar articular appendages as *Symbathocrinus*, which cover a good part of the ventral surface. The articulation, however, does not occupy the whole width of the radials; there is at each side of the plates an upright extension, which together with that of adjoining radials produces interradially, between the arms, a conspicuous projection, similar to that of *Haplocrinus*, but more prominent. The construction of the ventral side is not known, the space beyond the articular faces is open in all our specimens, but probably was covered in a similar manner as in *Symbathocrinus.*

The arms are long, simple, rounded along the outer face, and less closely folded than in *Symbathocrinus.* They are composed of extremely long, single joints with parallel upper and lower faces. The column is circular and has a stellate central canal.

Geological Position, etc.—*Pisocrinus* is restricted to the Upper Silurian, and occurs in Europe and America.

Pisocrinus Dixoni Troost is a catalogue name.

1878. **Pisocrinus flagellifer** Angelin, Iconogr. Crin. Suec., p. 21, Pl. 4, figs. 1 *a–e.* —Upper Silur., Gothland, Sweden.

1879. **P. gemmiformis** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (July), Pl. 9, figs. 6 *a–c.*—Niagara gr., Riply Co., Indiana.

1878. **P. ollula** Angelin, Iconogr. Crin. Suec., p. 21, Pl. 4, figs. 4 *a–d.*—Upper Silurian, Gothland, Sweden.

1858. **P. ornatus** De Koninck, Bull. de l'Acad. Roy. de Belg. (Ser. 2), Tome 4 (Extr. p. 27), Pl. 2, figs. 12, 13.—Upper Silurian, Dudley, England.

1858. **P. pilula** De Koninck (Type of the genus), Bull. de l'Acad. Roy. de Belg. (Ser. 2), Tome 4 (Extr. p. 26), p. 106, figs. 8–11; Angelin, 1878, Iconogr. Crin. Suec., p. 21, Pl. 4, figs. 4 *a, b.*—Upper Silurian, Dudley, England, and Gothland, Sweden.

1878. **P. pocillum** Angelin, Iconogr. Crin. Suec., p, 21, Pl. 4, figs. 3, 3 *a.*—Upper Silurian, Gothland, Sweden.

*1860. **P. tennesseensis** (Roemer), **Symbathocrinus tennesseensis**, Silur. Fauna, West. Tenn., p. 55, Pl. 4, figs. 6 *a, b.*—Niagara gr. Decatur Co., Tenn.

TRIACRINUS Münster.

1839. Münster, Beiträge z. Petrefactenk., p. 3.
1850. D'Orbigny, Prodr. de Paleont., i, p. 104.
1866. Schultze, Monogr. Echin. Eifel Kalk., p. 106.
1879. Zittel, Handb. d. Palæont., i, p. 348.
Syn. *Trichocrinus* Müller, Monatsber. 1856, p. 354., and Neue Echin. d. Eifl. Kalk., p. 248.

Triacrinus differs from *Pisocrinus* in having three basals in place of five, in all other characters the two forms are identical. We have some doubt whether the few species which have been referred to *Triacrinus* have not really five basals instead of three. In this case the genus would take the name *Pisocrinus* and not *Triacrinus*, although the latter has priority. Münster described the base as tripartite, making this the name-giving character, and De Koninck, who found five basals in his species, was in our opinion perfectly justified in establishing for it a new genus.

1857. **Triacrinus altus** (Müller), **Trichocrinus altus,** Neue Echin. Eifl. Kalk., p. 249, Pl. 2, figs. 8–11.—Schultze, 1866, **Triacrinus altus,** Echinod. Eifl. Kalk., p. 109, Pl. 12, fig. 9.—Devonian. Eifel, Germany.

1857. **T. depressus** (Müller), **Trichocrinus depressus,** Neue Echin. Eifl. Kalk., p. 249, Pl. 2, figs. 12–17.—Schultze, 1866, **Triacrinus depressus,** Echin. Eifl. Kalk., p. 108, Pl. 12, fig. 8.—Devonian. Eifel.

1839. **T. granulatus** Münster, Beitr. z. Petrefactenk., p. 4.—Upper Silur. (?). Schübekammer, Germany.

1839. **T. granulatus** Münster, type of the genus, Beitr. z. Petref., p. 3, Pl. 1, figs. 4 *a*, *b*, *c*.—Devonian. Benitzlosau, near Hof, Germany.

LAGENIOCRINUS De Kon. & Lehon.

1853. De Kon. and Lehon., Recherch. sur les Crin. Carbon. de la Belg., p. 187.

1879. Zittel, Handb. d. Palæontologie, i, p. 350.

Zittel has placed *Lageniocrinus* along with *Symbathocrinus* and *Phimocrinus*, and we think for good reasons. We also agree with him that the five plates, which in the specimens cover the ventral surface, represent the arms and not radials as was supposed by De Koninck. These plates evidently could be opened, and there were plates underneath covering the calyx. *Lageniocrinus* represents in our opinion an embryonic form, and may possibly be the young stage of *Symbathocrinus*. Of this genus we found a very minute specimen, in which the arms consisted of but three successive joints, forming jointly a pyramid; while adult specimens sometimes have as many as a hundred.

Generic Diagnosis.—General form flagon-shaped; that of the dorsal cup funnel-shaped. Basals three, elongate, two of them larger and pentangular, the smaller one rhomboidal, which together form a tubular body which is slightly wider above. The radials are quadrangular, wider above than below. Two of them rest upon the truncate upper faces of the two larger basals, the three others against their sloping sides and against the upper sides of the smaller basal. There is no anal plate. The arms consist of single joints, which, folded together, form a pyramid. The ventral surface of the calyx is not known.

1853. **Lageniocrinus seminulum** De Kon. and Lehon, Recherch. sur les Crin. Carbon. de la Belg., p. 189, Pl. 4, fig. 1 *a–c*.—Mountain limest. Visé, Belgium.

(?) **RHOPALOCRINUS** W. & Sp., Rev. i, p. 57.

This genus was referred by us provisionally to the Ichthyocrinidæ, where it cannot remain, as it has not the articulate structure so characteristic of that group. We now place it with the Inadunata, as the arms were evidently free from the first radials ; but we are yet in doubt if it should go with the Symbathocrinidæ, Cupressocrinidæ, Gasterocomidæ, or be made a distinct group.

FAMILY XV.—CUPRESSOCRINIDÆ Roemer.

The Cupressocrinidæ in our classification consist only of the genus *Cupressocrinus.* Schultze, Zittel and De Loriol, however, added *Symbathocrinus* and *Phimocrinus*, which unquestionably differ from *Cupressocrinus* more than *Pisocrinus* and *Triacrinus*, for which they proposed a separate group.

CUPRESSOCRINUS Goldfuss.

(Pl. 4, fig. 1.)

1826. Goldfuss, Petref. Germaniæ, i, p. 330.
1835. Agassiz, Mémoir Soc. des Sci. natur. d. Neuchatel, i, p. 198.
1838. Goldfuss, Nova Acta. Ac. Leopold. XIX, i, p. 330.
1839. Münster, Beitrage z. Petref., p. 3.
1845. F. Roemer, Leonh. and Bronn's Jahrbuch, p. 291.
1850. D'Orbigny, Prodrome de Paleont., i, p. 102.
1852. Quenstedt, Handb. d. Petref. (Ed. 1), p. 623.
1855. Sandberger, Versteinerungen Nassau's, p. 401.
1855. F. Roemer, Lethæa Geognostica (Ausg. 3), p. 230.
1857. Pictet, Traité de Paléont., vol. iv, p. 306.
1862. Dujardin and Hupé, Hist. natur. des Zooph. Echin., p. 110.
1866. Schultze, Monogr. Echin. Eifl. Kalk., p. 14.
1879. Zittel, Handb. d. Palæontologie, i, p. 348.
1880. Quenstedt, Handb. d. Petref., Ed. 3, p. 962.
1882. De Loriol, Paleontologie Franc., tome xi, p. 47, not Ad. Roemer, Harzegebirge, p. 8 ; nor McCoy, Syn. Brit. Palæoz. Foss., p. 117.
    Syn. *Halocrinites* Steininger, 1831, Mem. Soc. Géol. de France, i, p. 349.
    Syn. *Cypressocrinites* Steininger, 1849, Verstein. Uebergangsgeb. d. Eifel, p. 20.
    Syn. *Cypellocrinites* Steininger, 1853, Geogn. Beschr. d. Eifel, p. 36.

Goldfuss, in 1826 (Petrefacta Germania), gave a good description of this genus, to which he made additions in 1838 (Beiträge zur Petrefactenkunde, p. 334). At both times he expressed the conviction that the ventral covering was probably membranous.

The arms he described as bearing "säbelförmige Tentakeln" (pinnules), and in the description of *Cupressocrinus gracilis* he gave a graphic account of the articular facets of the radials. These, according to his statement, extend deeply inward, so as to diminish largely the width of the visceral cavity, which at the upper end is reduced to one half the depth of the facet. Behind the "Nahrungscanal" (axial canal), he says, there extend out two diverging muscular extensions, which connect by a cross-piece, abut against their fellows of adjacent radials, and form together a star-shaped figure, composed of five pairs of leaves. The ventral surface, therefore, according to Goldfuss, consists of five coalesced muscle-plates, and not, as was supposed by Roemer, Schultze and Zittel, and heretofore by ourselves, of an independent plate or apparatus, peculiar to this genus. F. Roemer described it as a cribriform calcareous plate, in form of a five-leaved flower. Schultze speaks of it as five delicate plates, which join radially, four of them equal, the fifth one different and containing the anal opening. He calls it a consolidating apparatus, constituting a part of the inner body, and not portions of the outer test; pierced by various openings, through which the blood-vessels, axial canals and genital organs passed into the arms. A similar view was held by Zittel, who stated: "There is in the interior of the calyx, at the base of the arms, a peculiar annular, so-called consolidating apparatus, composed of five large interradial (oral) plates, with a round (mouth) opening at the centre." Also, De Loriol mentions a peculiar "Consolidations-apparat, qui a été rapproché des hydrospires."

The views expressed by us, Rev. I, p. 12, to which De Loriol alludes, differ from those of our co-laborers. We held that the so-called "consolidating apparatus" was composed of five oral plates, which we thought stood in connection with five pairs of hydrospires. To this interpretation we were partly led by a certain superficial resemblance, but principally by the fact that Roemer, Schultze and Zittel, who had access to the splendid collections from the Eifel, all agreed that the plates in question were interradial in position. If this had been true, nothing could have been more natural but that these plates should be structurally identical with the deltoids of the *Blastoidea*, and the interradials of the *Cyathocrinidæ*, which were then held by us to be oral plates.

A very different interpretation of the so-called consolidating apparatus has been given to us by Dr. P. H. Carpenter, who regards it as representing the united muscle-plates of the radials. He wrote to us as follows: "I look upon the consolidating apparatus as offering a surface for the attachment of muscles by which the arms were moved on the calyx. The successive arm-pieces—I will not call them 'joints'—were suturally united and not movable upon one another, so that the arms were moved *en masse* upon the calyx, and this must have required very strong muscles between the calyx and first brachials. All that is ordinarily supposed to represent the articular face of the radials is shown in Schultze's Taf. II, fig. 5 *a*, while that of the arm-base appears on fig. 7 *b*. Now, it appears to me improbable that the heavy, massive arms of *Cupressocrinus* were moved by muscles which had no further surface of attachment—at their proximal end, at any rate—than is shown in Fig. 5 *a*. *Symbathocrinus* has large muscle-plates, but there is nothing of this kind in *Cupressocrinus*, without the consolidating plates. The calyx of *Phimocrinus lævis* (Schultze, Taf. III, fig. 6 *a*), corresponds to that of *Cupressocrinus*, with the consolidating plates *in situ*. There is the same arrangement round the anal opening, of which there is absolutely no trace in *Cupressocrinus*, *without* the consolidating plates, and yet it is clear from Schultze's description that he regards (rightly as I believe) the top of the calyx to be formed of the 'Gelenkflächen der Radialia,' with the anus between two of them. I cannot, therefore, help regarding the consolidating apparatus of *Cupressocrinus* as consisting of the united muscles-plates of the radials, from the lower portions of which they are apt to separate." This seems to us a very reasonable solution of the question, and we fully agree with Carpenter. We have since found that the plates are not interradially disposed, nor do they form separate pieces; the sutures which we thought we observed are evidently radial sinuses, similar to those which we described in *Symbathocrinus*.

The arm structure of *Cupressocrinus* was also pointed out more accurately by Goldfuss than by most of the succeeding writers. The outer and inner "Querbalken" of Schultze (Mon., Pl. 1, figs. 1 *h*, *α*, *β*), are obviously the basal portions of incurved pinnules, and as such they were described and figured by Zittel. These pinnules, however, in the opinion of Carpenter, are not homologous with those of other Crinoids, there being six or more of them to each arm plate, given off from each side, in place of one alternately arranged, a structure similar to that of the so-called pinnules of the Blastoids. Also their ambulacra, aside from not being recumbent and forming no part of the calyx, resemble closely those of the latter group. By removing the lancet piece and side pieces in *Pentremites*, and exposing the sinus, it will be found that the inner sides of the limbs are constructed almost exactly as the inner walls of the arm-grooves in *Cupressocrinus*, as seen by a comparison with Schultze's figure in his Monograph, Pl. ii, figs. 7 and 11. There are in both structures deep, rounded transverse grooves, alternating with ridges which are truncate above, and each one of them is provided lengthways with a small furrow at the top. These furrows do not extend to the full length of the ridge, but are provided at their outer end with an articular facet for the attachment of a pinnule. The pinnules at their base do not touch laterally, but leave a small open space in the direction of the lateral grooves. These grooves form the outer half of a pore, similar to the hydrospire pores of the Blastoids, and like the latter probably are communicating in a similar manner with hydrospires, lodged, however, within the arm grooves and not within the calyx. Schultze's figures 1 *h* and 1 *i*, in our opinion, are incorrect. *Cupressocrinus* certainly had no such "Tentakel-Furche" as here represented, and we doubt if the genus possessed such minute irregular covering plates, either along the perisome or within the arms.

Generic Diagnosis.—Dorsal side of the calyx basin-, cup- or bell-shaped, composed of rather large, heavy plates; when the arms are attached and closed, the form is ovoid or pyramidal.

The basals consist of five equal, pentagonal pieces, which enclose an equilateral, undivided disk, formed by a coalescence of the underbasals, or, according to others, by the upper stem joint which became enlarged and as such took the place of the underbasals in other genera.

Radials five, of similar form, wider than high, pentangular; the upper margins truncate, and forming a horizontal line. They are succeeded by five very short pieces, of the same width, which Schultze designated as "articularia" and as parts of the calyx. The arms are wide, simple, closely folded together, and composed of a single row of from 2 to 20 heavy, transverse pieces, of which the upper and lower sides are parallel. The arm plates grow narrower and shorter at their upper ends, they are suturally connected, and sometimes so closely anchylosed that no suture lines can be distinguished along the lateral margins of the arms.

The radials are connected with large muscle-plates (Pl. 4, fig. 1), which are laterally anchylosed, and together form one continuous plate. This covers the greater part of the ventral surface, leaving in the centre but a comparatively small, irregularly pentagonal open space, which, as we suppose from analogy with allied forms, was covered in the animal by interradial and summit plates. The median portions of each radial is pierced by two successive, rather large openings, of which the outer ones penetrate the upper margin of the plate, and serve as passages for the axial cords; the inner ones, which pass through the muscle-plate, probably are ambulacral openings. The muscle plate in its outer form is stellate, having five pairs of leaf-like extensions, two to each radial. They contain upon their outer faces indistinct striæ, which from both sides concentrate toward the axial opening. The leaves become more delicate toward the periphery, especially interradially, where they are frequently broken, and the spaces, thus formed, appear in the specimens as if constituting natural openings.

The articulation of the arms with the calyx was facilitated by the axillaria, which, like the radials, have an axial canal, and, according to Schultze, similar muscular processes. The articular face of the arms is truncate, sloping toward the inner side, and corrugated for the reception of ligament. The arm furrow is deep and wide, and contains along the inner floor an unusually large axial canal, which, to the extent of the proximal arm piece, is partitioned off from the ambulacral groove. The exact construction of the ambulacra is not known, but we judge they were plated in a similar manner as those of *Symbathocrinus*, and not membranous as described by Schultze. They probably also were provided with lateral pores, and these were alternately arranged with incurved, articulated pinnules, resembling in form those of the recent genus *Holopus*, but arranged like those of the Blastoids, there being four or more to each arm joint.

Cupressocrinus has been described to possess no anal plate, only an anal opening, located between two of the muscle plates.

It has been overlooked, however, that in the two radials adjoining the anal opening the passages of the axial cords are placed considerably to one side, leaving sufficient space for an anal plate such as we find in *Symbathocrinus*, and whose presence we postulated in *Phimocrinus*. That such a plate really existed, is more probable since we find in *C. gracilis* the margin which forms the anal opening at one side considerably raised, and there are irregular upper edges as if these had formed the base of an anal tube.

The column is circular, triangular or quadrangular, composed of short joints. It contains four large peripheral canals, rarely three or five, and a central one, which is either confluent with the others or isolated. It is frequently provided with cirrhi, which have two canals, vertically arranged, and these also are frequently confluent.

Geological Position, etc.—*Cupressocrinus* is only known from the lower portions of the Devonian of Europe.

N. B.—*Cupressocrinus dubius* and *C. teres* A. Roemer, and *C. pentaporus* Eichwald, were described from pieces of column; *C. calyx* McCoy = *Hydreionocrinus calyx* (Rev. ii, p. 131); *C. impressus* McCoy probably is *Eupachycrinus*.

1838. **Cupressocrinus abbreviatus** Goldf., Nova Acta Ac. Leopold. xix, Pt. i, p. 333, Pl. 30, fig. 4.—D'Orbigny, Prodr. i, p. 102.—Roemer, 1855, Leth. Geogn. (Ed. 3), i, p. 232.—Schultze, 1866, Echin. Eifl. Kalk., p. 19, Pl. ii, fig. 1, and Pl. iii, fig. 3.—Dujardin and Hupé, 1862, Hist. nat. Zooph. Echin., p. 112.—Devonian. Eifel, Germany.

Schultze recognized the following varieties: **C. alta, C. granulosa, C. hybida** and **C. minor.**

Syn. **Halocrinites Schlotheimii** Steininger, Mem. Soc. géol. de France i, p. 349, Pl. 21, fig. 1.

Syn. **Cupressocrinus Schlotheimii** Steininger, Geogn. Reschreib. d. Eifel, p. 36, and Verstein. der Eifel, 1849, p. 21.

Syn. **C. pyrimidalis** Stein., Bull. Soc. géol de France (Ser. i), ix, p. 295, Pl. 4.

Syn. **C. nodosus** Sandberger, Versteiner. Nassau's, p. 401, Pl. 35, fig. 5.

Syn. **C. Urogalli** Roemer, Palæontgr. iii, p. 9, Pl. 2, fig. 7.

1826. **C. crassus** Goldfuss (Type of the genus), Petref. Germaniæ i, p. 212, Pl. 64, fig. 4; also 1838, Nova Acta Ac. Leopold. xix, Pt. i, p. 331, Pl. 30, fig. 1.—Agassiz, 1835, Soc. de Neuchat. i, p. 198.—D'Orbigny, 1850, Prodr. i, p. 102.—Bronn., Lethæa Geogn. 1 and 2.—F. Roemer, Leth. Geogn. i, 1855 (Ausg. 3), p. 232, Pl. 4, figs 9 a, b, c.—Bronn, 1860, Classen des Thierreichs ii, Pl. 28, fig. 1.—Dujardin and Hupé, 1862, Hist. nat. Zooph. Echin., p. 112, Pl. 5, fig. 12.—Schultze, 1866, Mon. Echin. Eifl. Kalk., p. 23, Pl. 3, fig. 1.—Devonian. Eifel, Germany.

Syn. **Cypressocrinus crassus** Steininger, Geogn. Beschreib. d. Eifel, p. 36 and Versteiner. d. Eifel, p. 20.

Syn. **Cupressocrinus tetragonus** Goldfuss, Nova Acta Ac. Leopold. xix, Pt. i, p. 332, Pl. 30, fig. 3.

1838. **C. elongatus** Goldfuss, Nova Acta Ac. Leopold. xix, Pt. 1, p. 331, Pl. 30, fig. 2. —Münster, 1839, Beitr. d. Petrefactenk., p. 3, Pl. i, figs. 1 a, b.—D'Orbigny, 1850, Prodr. i, p. 102.—Schultze, 1866, Mon. Echin. Eifl. Kalk., p. 23, Pl. 3, fig. 1.—Dujardin and Hupé, Hist. natur. Zooph. Echin., p. 112.—Devonian. Eifel, Germany.
Syn. **C. gerolsteinensis** Stein, 1849, Verst. d. Eifel, 1849, p. 20.
Syn. **C. prismaticus** Stein, 1849, *ibid.*, p. 20.
Syn. **C. elongatus** Stein, Geogn. Beschreib. d. Eifel, p. 36.

1826. **C. gracilis** Goldfuss, Petref. Germaniæ, i, p. 213, Pl. 64, fig. 5: also Nova Acta Ac. Leopold. xix. Pt. I, p. 334, Pl. 30, figs. 5 *a*, *b*, *c* (not 5 *d*).—Steininger, 1849, Versteiner. d. Eifel, p. 20.—D'Orbigny, 1850, Prodr. i, p. 102.—Dujardin, and Hupé, 1862, Hist. nat. Zooph. Echin., p. 113.—Schultze, 1866, Mon. Echin. Eifl. Kalk., p. 23, Pl. 3, fig. 2.—Devonian. Eifel, Germany.

1866. **C. hieroglyphicus** Schultze, Mon. Echin. Eifl. Kalk., p. 25, Pl. 1, fig. 3.—Devonian. Eifel, Germany.

1866. **C. inflatus** Schultze, Mon. Echin. Eifl. Kalk., p. 24, Pl. 1, fig. 2.—Devonian. Eifel, Germany.

1866. **C. scaber** Schultze, Mon. Echin. Eifl. Kalk,, p. 25, Pl. 1, fig. 4.—Devonian. Eifel, Germany.

FAMILY XVI.—GASTEROCOMIDÆ.

The Gasterocomidæ embrace the following genera: *Gasterocoma*, *Nanocrinus* and *Myrtillocrinus.* They were united by Pictet and by Dujardin and Hupé, with the Haplocrinidæ; Roemer, Schultze, Zittel and De Loriol, however, treated them as a separate family.

GASTEROCOMA Goldfuss.

1838. Goldfuss, Nova Acta Ac. Leopold. xix, i, p. 350.
1853. Steininger, Geogn. Beschreib. d. Eifel, p. 38.
1857. Müller, Neue Echin. Eifl. Kalk., p. 257.
1857. Pictet, Traité de Paléont., iv, p. 314.
1862. Dujardin and Hupé, Hist. natur. des Zooph. Echin., p. 109.
1866. Schultze, Mon. Echin. Eifl. Kalk., p. 95.
1879. Zittel, Handb. d. Palæont., i, p. 363.
Syn. *Ceramocrinus* Müller, 1855, Verh. naturh. Verein f. Rheinlande, xii (n. ser.), p. 83.
Syn. *Epactocrinus* Müller, 1855, *ibid.*, p. 84.

Gasterocoma was described by Goldfuss to be composed of five basals and five radials, the latter as enclosing laterally an anal plate, and the anal opening as being located next to the posterior basal. This definition, although substantially correct, was afterwards modified by Schultze. He found that among species, and even among individuals of the same species, the construction of the azygous side undergoes most remarkable variations; such as in other groups would be sufficient for generic separation. The anal opening in this genus, as a rule, is located between the radials. It either lies directly above the posterior basal, and is followed by a quadrangular or triangular anal plate, or the opening is situated above the anal plate. In the former case the two posterior radials may close above the opening, or be separated from one another by additional plates; the opening may even penetrate exceptionally the posterior basal. Müller's genus *Ceramocrinus*, according to Schultze, was founded upon a specimen in which the anal plate was placed above the opening, contrary to the typical form of Goldfuss, in which it was below. The name *Epactocrinus* was proposed for a specimen with very irregular basals, portions of which evidently had been destroyed or fractured, and were restored by the animal, and this may have produced the irregular form. The construction of the ventral side cannot be satisfactorily ascertained from Schultze's figures. His figs. 1 *f*, and 1 *i*, on Pl. xii, which are said to represent the ventral surface of *Gasterocoma antiqua*, are so different from one another, that we believe there is a mistake in the figures. These figures differ again essentially from fig. 5 *b*, which is said to represent the same parts in *Gasterocoma gibbosa.*

Generic Diagnosis.— The lower disk has the form of a pentagon, and extend somewhat beyond the column. It is surrounded by five basals, four of them equal, pentagonal; the fifth larger, hexagonal, truncate above.

Radials five, pentangular; three of them are equal, the two next to the azygous side irregular. The two latter enclose laterally not only the anal plate, but also the anal opening, which is surrounded by a single ring of small plates, and either rests upon the truncated upper face of the larger basal, or is separated from the latter by an anal plate. In either case the anus, as a general rule, is succeeded by one or more anal pieces, which, however, in some specimens do not extend to the upper end of the radials, and in this case the radials meet above the anal plates. The radials have a lateral articular facet of the horseshoe form, which extends deeply into the plate. It is notched above for the arm furrow, and pierced by a large axial canal, which is removed far off from the outer edge of the plate. The arms evidently were heavy, and, to judge from the facets, were probably pendent.

The mouth of *Gasterocoma*, according to the position of the central piece, was excentric. This central—or, as we call it, oral—

plate abuts against the two posterior radials; it is large, heavy, somewhat elongate, and surrounded anteriorly and laterally by what may prove to be four proximals (?). The interradial plates appear to be small, but may be partly hidden from view by the large covering plates.

The form of the column is not known, but it was, like in *Cupressocrinus*, perforated with a central canal and four peripheral ones, which were confluent at the centre.

Geological Position, etc.—Confined to the Devonian of the Eifel.

The following species have been described:—

1838. **Gasterocoma antiqua** Goldf. (Type of the genus), Nova Acta Ac. Leopold. XIX, i, p. 96.—Pictet, 1857, Traité de Paléont., iv, Pl. C, fig. 7.—Schultze, 1866, Echin. Eifl. Kalk., p. 96, Pl. 12, fig. 1.—Devonian. Eifel, Germany.
Syn. **Epactocrinus irregularis** Müller (Wirtgen and Zeiler), 1855, Verh. naturh. Verein. f. Rheinl., xii, p. 85, Pl. 12, figs. 5–8.

1866. **G. gibbosa** Schultze, Echin. Eifl. Kalk., p. 98, Pl. 12, fig. 5.—Devonian. Eifel, Germany.

1866. **G. Mülleri** Schultze, Echin. Eifl. Kalk., p. 99, Pl. 12, fig. 2.—Devonian. Eifel, Germany.
Syn. **Ceramocrinus eifliensis** Müller (Wirtgen and Zeiler), Verh. naturh. Verein f. Rheinlande, xii, p. 83, Pl. 12, fig. 2.

1866. **G. reticularis** Schultze, Echinod. Eifl. Kalk., p. 99, Pl. 12, fig. 3.—Devonian. Eifel, Germany.

1866. **G. stellaris** Schultze, Echin. Eifl. Kalk., p. 100, Pl. 12, fig. 4.—Devonian. Eifel, Germany.

NANOCRINUS Müller.

1856. Müller, Monatsber. d. Berl. Acad., p. 355.
1857. Müller, Neue Echinod. Eifl. Kalk., p. 249.
1866. Schultze, Monog. Echin. Eifl. Kalk., p. 102.
1879. Zittel, Handb. d. Palæontologie, i, 364.

Nanocrinus is very closely allied to *Gasterocoma*, and had not Schultze found six specimens which all have the same irregular structure, we should feel inclined to regard it an abnormal form of that genus. According to Schultze, the genus has five basals, but only four radials; the place of the fifth one is said to be occupied by an interradial. The latter is strictly radial in position, and as such should be designated as a non-arm-bearing radial.

Generic Diagnosis.—Basal cup as in *Gasterocoma*, but the plates less regular; four of them pentagonal, the posterior one considerably higher, hexagonal, truncate above.

Radials five, large, irregular in size, four of them arm-bearing, the fifth one not. The articular facet is lateral, horseshoe-shaped, and occupies almost the whole outer face of the radials. Three of the plates have a single facet, but the fourth, which is an axillary, has two, somewhat smaller than those of the others. The non-arm-bearing radial is smaller by more than one-half than any of the rest; it is hexagonal or trapezoidal, and sometimes altogether absent. The anal plate is placed between the lateral faces of two radials, and rests upon the truncate upper face of the larger basal. It is subquadrangular, somewhat excavated for the anal opening, which generally occupies the upper portion of the anal plate, occasionally, however, as in *Gasterocoma*, the lower side of it. The form of the arms is unknown.

The interradials appear to be small, but probably are partly hidden from view by the unusually large covering pieces, which occupy the greater part of the ventral surface, and rest against the oral plate, which is extremely large, there being no proximals. The column, like that of *Gasterocoma*, is provided with a central canal and four peripheral ones.

The only known species is :—

1856. **Nanocrinus paradoxus** Müller, Monatsber. d. Berl. Acad., p. 355; also Neue Echin. d. Eifl. Kalk.. 1857, p. 249, Pl. 2, figs. 18–21.—Schultze, 1866, Echin. Eifl. Kalk., p. 102, Pl. 12, fig. 7.—Devonian. Eifel, Germany.

MYRTILLOCRINUS Sandberger.

1855. Sandberger, Versteiner. Nassau's, p. 388.
1857. Pictet, Traité de Paléont., iv, p. 311.
1862. Dujardin and Hupé, Hist. natur. des Zooph. Echinod., p. 108.
1862. Hall, 15th Rep. N. York St. Cab. Nat. Hist., p. 142.
1866. Schultze, Mon. Echin. Eifl. Kalk., p. 96.

We have not seen the original description of this genus, but we infer from the notes of Pictét, Schultze and Hall, that Sandberger described it to possess a quinque-partite, quadri-canaliculate base. In his figure it seems the central part was represented as undivided, and, curiously enough, the same is the case with Hall's figure of the American species, although he mentions in the description "five basals and five subradials." We cannot understand how a base like this could have been divided into five parts—not four—aud, therefore, prefer, in default of further evidence, to regard it as undivided, although we are well aware that, if any such division did exist, it would prove most satisfactorily that also the lower plate in the allied genera is underbasal. *Myrtillocrinus*, in our opinion, is closely allied to *Gasterocoma*, if not identical with it, but it is possible that the anal opening which has not been observed was subcentral, in place of lateral. It also appears from Hall's figure, as if it had two arms from each ray, although there is but one axial canal, which occupies the central space of the facet. The facet in Hall's species is oval and strictly lateral, thus indicating that the arms were pendent.

Geological Position, etc.—Only two species are known, the one from Europe, the other from America, both coming from lower Devonian beds.

1862. **Myrtillocrinus americanus** Hall, 15th Rep. N. York St. Cab. Nat. Hist., p. 142, Pl. 1, figs. 2-4.—Upper Helderberg group. Livingston Co., N. Y.

1855. **M. elongatus** Sandberger (type of the genus), Verstein. Nassau's, p. 388, Pl. 35, fig. 6.—Pictet, Traité de Paléont., iv, p. 311, Pl. c, fig. 4.—Dujardin and Hupé, 1862, Hist. natur. d. Zooph. Echinod., p. 108.—Müller, 1857, Neue Echin. Eifl. Kalk., p. 257.—Devonian. Nassau, Germany.

b. *Branch*, FISTULATA, W. and Sp.

The Fistulata embrace the Cyathocrinidæ as they were defined by us heretofore, but which we now subdivide into Hybocrinidæ, Heterocrinidæ, Anomalocrinidæ, Cyathocrinidæ and Poteriocrinidæ. To these we add the Belemnocrinidæ, Astylocrinidæ and Encrinidæ.

Zittel defined his Hybocrinidæ as follows: Calyx irregular; basis monocyclic; basals 5; radials 5; arms slender, single-jointed; pinnules wanting; and he placed in the family: *Hybocrinus* and *Anomalocrinus*. His definition is deficient and not quite correct. It would admit *Pisocrinus* and *Rhopalocrinus*, which we recognize as members of very different groups; and it actually excludes *Anomalocrinus*, which has seven plates in the radial series and not five, and strong pinnules, which are wanting in *Hybocrinus*.

Hybocrinus represents a very peculiar form. No other palæozoic Crinoid deserves in so high a degree the designation *embryonic type* as this genus, *Hybocystites* and the allied genera *Hoplocrinus* and *Bærocrinus*, which Zittel took to be synonymous with *Hybocrinus*. These four genera, which are easily recognized by their monocyclic base, large body, imperfectly developed radial plates, small ventral sac, the embryonic state of their arms, and the absence of pinnules, will be recognized by us as Hybocrinidæ.

Among the Heterocrinidæ Zittel placed *Heterocrinus*, *Graphiocrinus*, *Erisocrinus*, *Philocrinus* and *Stemmatocrinus*.

The family was defined as follows: Calyx regular; base monocyclic or dicyclic (five underbasals and five basals, or the latter only); five radials; arms long, simple, rarely bifurcating. The qualification " calyx regular " cannot be applied to *Heterocrinus*, which is one of the most asymmetrical forms of the Palæocrinoidea, and this want of symmetry extends not only to the interradial series but also to the radial plates, and forms its best generic distinction.

Neither does that term apply to *Graphiocrinus*, which is bilateral, nor *Philocrinus*, which we think is decidedly irregular. Only *Stemmatocrinus* and *Erisocrinus* have a pentamerous calyx, but these agree in other respects with the Poteriocrinidæ. *Heterocrinus*, in its general asymmetry, in arms and pinnules, and in its azygous side, closely resembles *Anomalocrinus*, which for other reasons we refer to a distinct family. We add to the Heterocrinidæ the two genera *Stenocrinus* and *Ohiocrinus*, which are founded upon species heretofore ranged under *Heterocrinus*, and unlike Zittel, place *Graphiocrinus*, *Philocrinus*, *Stemmatocrinus* and *Erisocrinus* under the Poteriocrinidæ.

Anomalocrinus, which we make the type of a distinct family, stands closer to the Heterocrinidæ than to the Hybocrinidæ, but differs from either of them very essentially in the relative size of the calyx, which is comparatively large, and low-cup or saucer-shaped in place of subcylindrical or narrowly turbinate. It further differs from all known Crinoids, recent or fossil, in the arrangement of its pinnules, which are not given off alternately from opposite sides, but from every successive joint on one side at a time from one bifurcation to the next, where they change on both rami to the opposite side. In the arrangement of the anal plates, and in having no underbasals, the Anomalocrinidæ agree with the Heterocrinidæ.

The Belemnocrinidæ, which only contain *Belemnocrinus* and the imperfectly known genus *Holocrinus*, differ from the preceding families in having no underbasals; they have, however, large basals, cylindrically arranged, but even these take little or no part in forming the visceral cavity. In this regard *Belemno-*

crinus resembles *Rhizocrinus*, but it differs from that in having a strong porous ventral sac.

Zittel's Cyathocrinidæ include *Cyathocrinus*, *Nipterocrinus*, *Barycrinus*, *Euspirocrinus*, *Ophiocrinus*, *Botryocrinus*, *Palæocrinus*, *Carabocrinus*, *Sphærocrinus* and *Pachyocrinus* (Billings, not Eichwald), with the following family diagnosis: Calyx globose; basis dicyclic, composed of five underbasals and five basals; anals 1–3; arms strongly developed, single-jointed, long, branching, without pinnules; ventral side covered by "oral plates." From his list must be excluded *Nipterocrinus*, which has interradials and only three underbasals, and *Pachyocrinus*, which is too imperfectly known to determine its position. There are besides *Sicyocrinus*, *Ophiocrinus*, *Botryocrinus* and *Barycrinus*, in which the arms, throughout their whole length, give off armlets at intervals, which evidently take the place of pinnules if they are not true pinnules themselves. We direct attention to this point, as both Zittel and De Loriol make the absence of pinnules in the Cyathocrinidæ the sole distinction between this family and the Poteriocrinidæ.

The presence or absence of pinnules has been considered by us heretofore as a doubtful character for distinguishing families. The pinnules are extensions of the arms, and in their organization, both morphologically and physiologically, almost identical with the arms. They are short branchlets given off along the sides of the arms, but ordinarily not extending to their tips. The pinnules differ from arms only by their containing the fertile portions of the genital glands, while the arms lodge the genital cord. The branches of the arms may be said to be modified pinnules, which differ from true pinnules in their greater length and thickness. They are usually called arms when attaining the form and length of the primary arms, but armlets when shorter, less robust, and given off at regular intervals. Frequently the branches are pinnule-bearing again, and this is the case in the Poteriocrinidæ, in which all arms, whether branching or simple, main arms or side arms, are fringed with true pinnules. The presence or absence of pinnules would prove to be a much better character for distinguishing the two groups, were it not that *Barycrinus* and allied genera represent a most perplexing transition form in having short side branchlets, given off at regular intervals, and these branching off once or twice again in a similar manner. In these genera it is exceedingly difficult to determine whether the branches are armlets or pinnules, a question which cannot be decided definitely until we know where the genital glands are located. It is probable that in the genus *Cyathocrinus*, at least in its Carboniferous form, all branches were arms. We found in *C. multibrachiatus*, along the three or four proximal arm joints, outside the adambulacral or side-pieces, small plates in rows of from four to six pieces (Pl. 4, fig. 7 *a*, *b*), succeeding each other longitudinally, which perhaps took the place of the genital pinnules. No such plates, however, were represented in *Barycrinus*, in which the ventral grooves are comparatively narrow. *Cyathocrinus longimanus* has no regular pinnules, but certain sabre-shaped appendages, composed of five segments, which from each side infold over the ventral furrow, covering it completely. These appendages which we (Rev., i, p. 25) erroneously took to be rudimentary pinnules,[1] perhaps correspond with the so-called "pinnules" of the Cupressocrinidæ and Blastoidea.

Another good distinction between the Cyathocrinidæ and Poteriocrinidæ is offered by their mode of articulation. The radials of the former have horseshoe-like facets for the brachials; in the Poteriocrinidæ they are more or less truncate along the upper margin, and united with the brachials by a transverse ridge, occupying a median line and frequently their entire width. The middle part of this ridge is pierced by an axial canal, and there is a kind of muscle plate with more or less conspicuous fossæ. The outer edge of the plate is dentated and evidently was occupied by ligamentous bundles. In the Cyathocrinidæ the arms are always bifurcating, and their branches are given off at close intervals; those of the Poteriocrinidæ are frequently simple from the brachial bifurcation upwards, but when bifurcating, the divisions are given off irregularly, and branches and main arms bear pinnules alternately from every joint; there being no syzygies. The arm joints of the former, with the exception of *Barycrinus*, are composed of long, slender joints with almost parallel sutures; those of the latter are shorter, heavier and strongly wedge-shaped, even interlocking. The same mode of articulation that unites radials and brachials, extends to all bifurcating plates of the Poteriocrinidæ. In *Erisocrinus*, *Eupachycrinus* and *Graphiocrinus*, species with ten arms, it is found also among the proximal arm plates, not, however, in the allied *Scytalocrinus* and *Decadocrinus*, in which all arm plates above the brachials are united by suture or elastic ligament. The same was probably the case in species with branching arms, in which all intermediate joints between the axillaries are without either ridges or fossæ. A sutural union also connects the brachials in cases where they consist of more than one plate, the apposed faces showing no traces of a syzygy or fossæ. In the arms of the Cyathocrinidæ there are, so far as observed, no articular ridges nor axial canals, and no ligamentous fossæ, not even between radials and brachials, nor upon the axillaries. The apposed faces of all their joints fit closely together, the distal end being slightly concave, the proximal to the same degree convex, so that we may assert that their mode of union has been either by suture or of a somewhat similar nature, and that the arms were either immovable or their motions limited, and probably of a mere passive character. This difference in the articulation of the two types was noticed by J. S. Miller when describing the typical genera, for he placed *Cyathocrinus* separately among Inarticulata, and *Poteriocrinus* among Semiarticulata. These names, as applied to the rays, are very characteristic of the two groups, for the Poteriocrinidæ are in their articulation much more highly differentiated, approaching in some cases the Neocrinoidea, Miller's Articulata.

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[1] A similar interpretation at that time was given by us of the ambulacral plates covering the arm furrows of *Cyathocrinus iowensis*, a mistake which was rectified by Carpenter (Chall. Rep., pp. 63–66).

In none of the Poteriocrinidæ has the ventral covering, with the exception of the so-called ventral sac, ever been observed, while that of the Cyathocrinidæ is comparatively well known. This, however, is partly explained by the condition of the radials, which in the Cyathocrinidæ had ample space for the reception of interradials, contrary to the Poteriocrinidæ, in which the articulation extends over the whole width of the radials, and the interradials, partly or wholly, had to rest against the muscle plates as in the Symbathocrinidæ. In the Cyathocrinidæ the interradials were persistent through life, but they may have become resorbed in the Poteriocrinidæ before reaching maturity. The condition of the ventral side among the Cyathocrinidæ varies considerably, and even among the species now referred to the genus Cyathocrinus there are several which range infinitely lower than others, and these should be placed under new genera.

The azygous side of the Cyathocrinidæ consists rarely of more than two plates in the calyx—the azygous plate and the anal piece; but the Poteriocrinidæ generally have three, owing to the fact that the first plate of the ventral tube extends often into the calyx. The ventral sac is perhaps more club- or balloon-shaped in the Poteriocrinidæ, more cylindrical in the Cyathocrinidæ.

We subdivide the Cyathocrinidæ into:

DENDROCRINITES, genera with a large azygous and well-developed anal plate, embracing: *Merocrinus*, *Carabocrinus*, *Dendrocrinus*, *Homocrinus*, *Ampheristocrinus* and *Parisocrinus.*

BOTRYOCRINITES, genera having no special azygous plate or occasionally a rudimentary one, and armlets in place of pinnules: *Atelestocrinus*, *Vasocrinus*, *Botryocrinus*, *Sicyocrinus*, *Streblocrinus* and (?) *Barycrinus.*

CYATHOCRINITES, genera without azygous plate, with branching arms without pinnules: *Cyathocrinus*, *Arachnocrinus*, *Gissocrinus*, *Sphærocrinus*, *Achradocrinus*, *Codiacrinus* and (?) *Lecythiocrinus.*

Zittel placed *Gissocrinus* among the Taxocrinidæ, the perfectly symmetrical *Codiacrinus* among the most unsymmetrical Gasterocomidæ, and *Ophiocrinus*, *Dendrocrinus* and *Homocrinus*, which are devoid of true pinnules, among the Poteriocrinidæ.[1]

We subdivide the Poteriocrinidæ as follows:

POTERIOCRINITES, genera having an azygous plate, a regular anal piece, and the first plate of the ventral sac enclosed in the calyx: *Poteriocrinus*, *Scaphiocrinus*, *Scytalocrinus*, *Decadocrinus*, *Woodocrinus*, *Zeacrinus*, *Hydreionocrinus*, *Cœliocrinus*, *Eupachycrinus*, *Cromyocrinus* and *Tribrachiocrinus.*

GRAPHIOCRINITES, genera without azygous or anal plate, but the first plate of the sac within the limits of the calyx: *Graphiocrinus*, *Bursacrinus*, *Phialocrinus* and *Ceriocrinus.*

ERISOCRINITES, genera without azygous or anal plate dorsally: *Erisocrinus* and *Stemmatocrinus.*

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[1] Prof. Zittel figures, Handb. d. Palæont., i, p. 359, as type of the Poteriocrinidæ a species devoid of pinnules. *Poteriocr. curtus* Müller, is evidently a *Homocrinus.*

Our Poteriocrinidæ contain essentially the same genera as those of Zittel, but we except from his list *Homocrinus*, *Dendrocrinus*, *Agassizocrinus* and *Belemnocrinus*. For the two latter we propose distinct families.

The Encrinidæ are closely allied to the Poterocrinidæ, and we think will ultimately be consolidated with them. Nothing, as yet, is known of their ventral structure, but neither of that of the Poterocrinidæ except their ventral tube. There is nothing which proves that the ventral surface of *Encrinus* was composed of soft parts, or that it was exclusively perisomic or differed from that of the Poteriocrinidæ which are universally regarded as Palæocrinoids. The only difference which we have discovered is that in the Encrinidæ the brachials are united by syzygy and also the proximal arm plates; contrary to the Poteriocrinidæ in which syzygies, so far as known, do not occur.

Among *Astylocrinidæ*, which represent the free floating Palæocrinoidea, we include *Agassizocrinus* and *Edriocrinus*, the former with underbasals, the latter with basals only. It is very possible that *Edriocrinus* will prove to be the type of a distinct family.

The *Catillocrinidæ* contain: *Catillocrinus* and *Mycocrinus*. The allied Calceocrinidæ only the genus *Calceocrinus*.

These ten families are defined by us as follows :—

A. HYBOCRINIDÆ. Base monocyclic; calyx large compared with the arms. Basals 5, unusually large. Radials irregular, the postero-lateral one either unrepresented or very much smaller, and sometimes non-arm-bearing. Arms frequently undeveloped in one or more rays, or recurrent and appressed onto the outer surface of the calyx; simple, and without pinnules. Azygous side composed of a single, large azygous plate, and frequently an anal piece, which in form resembles the right posterior radial. Ventral sac very small, consisting of a mere tumor-like protuberance.

B. HETEROCRINIDÆ. Base monocyclic. Calyx small; plates irregular. Basals 5, variable. Radials irregular, frequently compound in one or more rays; the right posterior radial smaller, resting upon the azygous plate. Brachials consisting of two or more pieces, united by syzygy. Of the succeeding arm joints only every second, third or fourth one pinnule-bearing. Azygous plate large; anal plate consolidated with the right posterior radial, which toward the left supports a series of anal plates; toward the right the brachials. Arms long; the pinnules sometimes take the form of arms, and attain the same general height. Column tri- or quinque-partite.

C. ANOMALOCRINIDÆ. Base monocyclic. Form irregular. Calyx capacious. Azygous plate large; supporting the right posterior radial, which toward the right is succeeded by a row of brachials, and toward the left by the ventral tube. Arms composed of large quadrangular joints, giving off pinnules from one side only, from one bifurcation to the next, when all pinnules change to the opposite side. Column strong, central canal wide, stelliform, its projecting angles directed interradially.

D. BELEMNOCRINIDÆ. Base monocyclic. Basals large; cylindrical; solid, only pierced by a narrow central canal with a shallow concavity at its upper end. Radials small, quadrangular, enclosing an anal plate of the same form. Ventral sac large, club-shaped. Arms long with numerous syzygies, only every second or third joint pinnule-bearing. Pinnules long, often bifurcating. Column round or pentangular, frequently with long cirrhi given off interradially.

E. CYATHOCRINIDÆ. Base dicyclic. Calyx globose, rarely turbinate. Radials with horseshoe-like lateral facets supporting at least two, but frequently several more brachials. Arms without true pinnules, but with branches in regular succession to their tips. Arm joints with a few exceptions long and narrow; quadrangular with almost parallel sides; united either by suture or ligament, apparently not by muscles. Ventral sac large, cylindrical. Column round or pentagonal; central canal rather above medium size, pentagonal, the projections directed radially.

F. POTERIOCRINIDÆ. Base dicyclic. Calyx deep and turbinate, or shallow and disk-like, owing to the form of the underbasals, which are either extended into a cup, or are turned inward and concave. Radials somewhat irregular, of variable size, the right posterior one generally smaller; all truncated at the upper face. Brachials one or two, connected by suture; the lower or proximal face truncate. Arms simple or branching, with pinnules alternately arranged from every joint; without syzygy. Arm joints cuneate or interlocking. Articulation between brachials and radials by muscles and ligament, and also between the upper faces of all axillaries and succeeding plates. Ventral sac large, frequently inflated. Column more or less pentagonal, its outer angles placed interradially, the cirrhi radially.

G. ENCRINIDÆ. Dicyclic. Closely allied to the Poteriocrinidæ, but, *as a rule*, without anal plates. Basals with well-developed axial canals proceeding to the radials. Their brachials composed of two pieces, united by syzygy, frequently with other syzygies in the higher portions of the arms. Arms biserial or uniserial.

H. ASTYLOCRINIDÆ. Pedunculate in earlier life, detached from the column and free-floating in the adult, but not cirrhus-bearing. Plates of the calyx massive, and hence the visceral cavity comparatively small. Underbasals present or absent, and also the azygous piece is sometimes wanting; while the anal plate is always well developed.

I. CATILLOCRINIDÆ. Base monocyclic. The pentamerous symmetry greatly disturbed by the unequal size of the radials. Those of the antero-lateral rays much larger and supporting many more arms. Arms simple; composed of single joints resting directly upon the radials, with a separate socket for each arm, and a furrow for each ambulacrum. Anterior ray, and both posterior rays rarely with more than one arm each. There is no azygous nor special anal plate, one of the posterior radials supports towards the left a large ventral tube, composed of a single row of heavy curved plates, longitudinally arranged, with an open furrow along their inner, *i. e.*, ventral side. Column circular.

J. CALCEOCRINIDÆ. Base monocyclic. Calyx laterally depressed; hanging downward from the column; composed of three unequal basals, three arm-bearing radials, and two azygous radials without arms. Basals and radials united by ligament, and toward the anterior side by muscles also. In the normal position of the crinoid, the basals are located posteriorly, and the three radials at the opposite side. Anterior radial smaller, compound; composed of two pieces, which frequently are separated by the overhanging sides of the two lateral radials. Arms of the lateral rays more numerous and branching; anterior ray with a single arm, which sometimes dichotomizes toward the upper end. Anal tube as in the *Catillocrinidæ*.

FAMILY XVII.—HYBOCRINIDÆ Zittel.

(Emend. W. and Sp.)

BAEROCRINUS Volborth.

1864. Volborth, Eine neue Crinoideen Gattung. (Author's copy, p. 35).
1865. Volborth, Bulletin St. Petersb. Acad., vol. viii, p. 178.
1866. Volborth, Bulletin Soc. Imp. de Nat. de Moscow, ii, p. 442.
1867. Grevingk, Archiv. f. Naturkunde Liv.-Ehst. und Kurlands, Ser. I, vol. iv, p. 110.
1867. Grevingk, Uber *Hybocrinus dipentas* and *Baerocr. Ungarni*, Dorpat, p. 14.
1882. P. Herb. Carpenter, Quart. Journ. Geol. Soc. London, August, pp. 298-312.
1883. W. and Sp., Amer. Jour. Sci., vol. xxvi, November, p. 365.
Syn. *Homocrinus* Eichwald (in part), 1865–66; *Hybocrinus* Schmidt (in part), 1874; Zittel (in part), 1879.

The genus *Baerocrinus* has been a subject of much controversy ever since 1864, owing to doubts whether the genus should be admitted or rejected. It is unnecessary to give again a full history of these controversies, for which we refer to Dr. P. H. Carpenter's paper "On the Relations of *Hybocrinus*, *Baerocrinus* and *Hybocystites*," and to our notes "On *Hybocrinus*, *Hoplocrinus* and *Baerocrinus*," in the American Journal, of 1883. Carpenter agrees with us and with Volborth and Grevingk that *Baerocrinus* is a good genus, and not, as suggested by Eichwald and Schmidt, an abnormal specimen of *Hybocrinus dipentas.* There has been also much difference of opinion as to the meaning of certain plates. The type specimen has on its surface, along the basi-radial suture, and between two of the plates within the second or so-called radial ring, a peculiar structure, composed of numerous, irregular pieces, and upon this, principally, Volborth founded the genus. He took this structure to be a madreporic body; while Grevingk, Eichwald and Schmidt held it to be an accidental break in the test, due to mechanical agencies. Carpenter considered it to be the regular anal opening. He pointed out that it had the position of the anus in the Pentacrinoid larva at its earlier phases.

We stated in our paper that we did not agree with any of those views. We think it possible that this structure may have served as an anal opening, but as an abnormal one, which had opened out when the regular opening became functionally defective. We also differ from other authors in our interpretation of the plates. Those of the second circlet have been regarded all five as radials, and the calyx to the top of the radials as being perfectly symmetrical. It looks to us unreasonable, when we compare *Baerocrinus* with *Hoplocrinus* and *Hybocrinus*, and finding their structure in other essential points almost identical, that the one genus should be almost perfectly symmetrical, the other extremely irregular. And, therefore, it is probable that one of the non-armbearing so-called radials represents an azygous plate, such as we find in most of the *Fistulata*, that the right posterior radial and the anal plate were as yet undeveloped, and that *Baerocrinus* had but four radials. This interpretation of the plates, it seems to us, is corroborated by the gradual disappearance of the azygous plate among allied forms in palæontological times, and by the contemporary increase in the dimensions of the right posterior radial and the anal plate. The two latter pieces probably were absorbed from the azygous plate: at first the posterior radial, which in *Hoplocrinus* took the right upper corner, the left side remaining intact; afterwards in *Hybocrinus* the anal piece, which absorbed the left corner of the plate also.[1]

All this goes to prove that *Baerocrinus* represents a very low organization, or is, according to P. H. Carpenter, " a permanent larval form."

Revised Generic Diagnosis.—Form of the calyx cup- or goblet-shaped. Underbasals wanting. Basals five, subequal and comparatively large.

Radials large, irregular, only four of them developed, the right postero-lateral one absent. Three of the plates equal, the fourth one narrower. A large azygous plate occupies the same range with the radials and, like these, rests alternately upon the basals. It is undivided, and resembles the radials in form. In the type specimen only three of the radials are arm-bearing, the smaller one not having even an arm-facet. Arms five, simple throughout, composed of single quadrangular joints and destitute of pinnules; the ventral grooves lined by alternate plates. Form of the anus, ventral covering and length of arms unknown.

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[1] In our paper on *Hybocrinus*, *Hoplocrinus* and *Baerocrinus*, we stated that probably the azygous plate of the latter was homologous with the anal plate as represented in the larva of *Antedon*. In making this statement we had overlooked the fact that the latter plate is simply an interradial with special function, while the azygous plate in *Baerocrinus* is as much radial as interradial. They both agree, however, in being absorbed by other plates ; the azygous plate palæontologically by the right posterior radial and anal plate, the other in the growing animal over the whole surface.

Remarks.—In our analysis, we have taken the absence of the right posterior radial to be a fixed character. It is, however, possible that this plate was exceptionally undeveloped in the type specimen, and in this case *Baerocrinus Ungerni*, the only known species of the genus, must be placed under *Hoplocrinus.*

1864. **Baerocrinus Ungerni** Volborth, Bull. de l'Acad. des Sci. de St. Petersburg of 1865, tome viii, p. 178, with plate (adv. sheet), November, 1864, p. 37.—Eichwald, 1859, described and figured under the name of **Homocr. dipentas** Lethæca Ross., v, p. 183; and 1865, Bull. de Moscou, iii, p. 160.—Volborth, 1865, **Baerocr. Ungerni,** Bull. de Moscou, iv, p. 442.—Eichwald, 1866, **Homocr. dipentas,** Bull. de Moscou, i, pp. 149–161, Pl. 8, fig. h.—Grevingk, 1867, **Baerocr. Ungerni,** Ueber **Hoplocr. dipentas** and **Baerocr. Ungerni,** with plate; also Arch. f. Naturk. Liv. Ehst. and Kurlands, Ser. I, vol. iv, p. 110.—Schmidt, 1874 **Hybocrinus dipentas,** Memoires de l'Acad. Imp. des Sci. de St. Petersb., Ser. vii, tome xxi, No. 11, p. 3, Pl. 1, Figs. 1–2.—P. Herb. Carpenter, 1882, **Baerocr. Ungerni,** Quart. Jour. Geol. Soc. London (August), pp. 298–312.—W. and Sp., 1883, **Baerocr. Ungerni,** Amer. Jour. Sci., vol. xxvi, November, p. 365.—Brandschiefer, Lower Silurian. Erras, Russia.

HOPLOCRINUS Grevingk.

1867. Grevingk, Ueber *Hoplocr. dipentas* and *Baerocr. Ungerni*, p. 9.

1867. Grevingk, Arch. f. Naturk. Liev.-Ehst. und Kurlands, Ser. I, vol. iv, p. 110.

1883. W. and Sp., Amer. Jour. Sci., vol. xxvi, November, p. 365.

Syn. *Apiocrinus*, 1843, Leuchtenberg; 1856, Eichwald.—*Homocrinus*, 1859, Eichwald.—*Hybocrinus*, 1864, Volborth; 1874, F. Schmidt; 1879, Zittel; 1882, Carpenter.

Volborth, F. Schmidt, Zittel and Carpenter have made *Hoplocrinus* a synonym of *Hybocrinus*, although they admit that the two forms differ in the construction of their azygous side. We have heretofore directed attention to the fact that the differences in the number and arrangement of the azygous and anal plates have been generally regarded as good characters for distinguishing genera, and especially among the *Cyathocrinidæ* and allied families in which those plates frequently form the only means for generic separation. That the one azygous plate in *Hoplocrinus* is equivalent to the two in *Hybocrinus*, which we have fully admitted, does not warrant an exception in this case, as the differences in the arrangement of the respective plates are evidently the result of modifications from one to another. We, therefore, accept Grevingk's genus, and give the following—

Generic Diagnosis.—General form pyriform, more protuberant upon the azygous side. Calyx composed of five basals, four large radials, and a large azygous plate. The latter with its left side extending to the upper margins of the four large radials, its sloping right side supporting the fifth radial, which is small and triangular, and, taken jointly with the azygous piece as one plate, the two resemble in form the four large radials, only that the arm-facet is pushed to one side.

Basals large, pentagonal, nearly equal in size. Four of the radials pentagonal, the smaller one subtriangular, resting upon the right sloping upper side of the azygous plate, which is irregularly pentagonal. Arm-facets occupying scarcely one-third of the width of the radials. Arms simple, without pinnules; composed of quadrangular joints, arranged parallel to each other. Column cylindrical.

The only known species is:

1843. **Hoplocrinus dipentas** Leuchtenberg (**Apiocrinus dipentas**), Beschreibung neuer Thierreste d. Urwelt von Zarskoje. Selo, p. 17, Tab. ii, figs. 9–10; also Eichwald, 1856, Bull. de Moscow, i, p. 115.—**Homocrinus dipentas**, 1859, Eichwald, Leth. Ross., v, p. 583, Tab. 31, figs. *a–c* (excl. specimen from Erras).—**Hybocrinus dipentas**, 1864, Volborth, Bull. d. l'Acad. de. St. Petersb., Tome viii, p. 178.—**Homocrinus dipentas**, 1865, Eichw., Bull. d. Moscow, No. iii, p. 159.—**Hybocrinus dipentas**, 1865, Volborth, Bull. de Mosc., No. iv, p. 443.—**Homocrinus dipentas**, 1866, Eichwald, Bull. de Moscow, No. 1, pp. 149–161, Tab. 8, figs. 2, 3, 4.—**Hoplocr. dipentas**, 1867, Grevingk, Uber, **Hoplocr. dipentas** and **Baerocr. Ungerni**, p. 10, figs. 1 *a–f*; also Arch. für Naturk. Liv. Ehst. und Kurlands (Ser. i), Vol. iv, p. 110.—**Hybocrinus dipentas**, 1884, Schmidt, Memoires de l'Acad. Imp. des Sci. de St. Petersb., Tome xxi, No. 11, p. 3, Pl. i, figs. 4, 5, 6; also Carpenter, 1882, Quart. Journ. Geol. Soc. London (August), pp. 298–312.—**Hoplocr. dipentas**, 1883, W. and Sp., Amer. Journ. Sci., Vol. xxvi (November), p. 365.—Vaginaten Kalk., Low. Silur. Pulkowa, Russia.

HYBOCRINUS Billings.

1857. E. Billings, Geol. Surv. Can. for 1853–56 (Rep. of Progr.), p. 275.
1859. E. Billings, Geol. Surv., Decade iv, p. 23.
1879. Zittel, Handb. d. Palæont., i, p. 350.
1879. W. and Sp., Rev. of the Palæocr., i, p. 74.
1880. Wetherby, Journ. Cincin. Soc. Nat. Hist. (July).
1882. Carpenter, Quart. Journ. Geol. Soc. London (Aug.), pp. 298–312.
1883. W. and Sp., Amer. Journ. Sci., Vol. xxvi, p. 365.

When we defined *Hybocrinus*, Rev., Pt. i, p. 74, we regarded it as synonymous with *Hoplocrinus* and *Baerocrinus*, which, we have since shown, are generically distinct. However, in our late paper in the Amer. Journal we made some remarks upon the azygous side, which must be modified. We asserted that the upper end of the anal plate possessed a peculiar crenulated surface, a structure which Wetherby had previously described, and which we thought we had observed also in some of his specimens. The fact that the so-called "crenulation" was visible, more or less, in every specimen which Wetherby had sent us for comparison, led us to believe that it was an organic structure, probably of a similar nature as the pectinated rhombs of the Cystidea. We are now satisfied that we had not sufficiently taken into consideration the peculiar state of preservation of Wetherby's specimens, which are not only highly silicified, but the surface of the plates is badly weathered, and more or less destroyed. Through the kindness and liberality of Mr. Walter Billings we are now enabled to give a more satisfactory interpretation of these parts. On receiving our paper he promptly informed us that in the Canadian species of *Hybocrinus* the azygous plate was not crenulated, but crowded by numerous, very small pieces, forming a short pyramid. He accompanied his description with good figures, and offered us his specimens for examination. In these we found, resting upon the upper side of the anal plates, several rows of minute subquadrangular pieces, about six to the width of the plate, which together form a tumular protuberance without any visible opening. There appear, however, minute pores along the sutures, and it is evident that the protuberance represents a ventral sac, reduced to its minimum size. The crenulated appearance in Wetherby's specimens is evidently the result of weathering, the apparent grooves representing the sutures between the small plates. A similar short protuberance has been observed in *Hybocystites*, and in all probability was present in the two other genera.

No new species of this genus have been described since our first discussion. We found several specimens in the Trenton limestone, near Knoxville, Tennessee, but none of them perfect enough for specific identification.

HYBOCYSTITES Wetherby.

(Revised by W. and Sp.)

1880. Wetherby, Cincin. Journ. Nat. Hist. (July).
1882. P. Herb. Carpenter, Quart. Journ. Geol. Soc. London, pp. 298–312.

Hybocystites combines, in a remarkable degree, some of the characters of Palæocrinoidea, Cystidea and Blastoidea. Wetherby describes it as a Cystid, Carpenter was more inclined to place it with the Blastoids; while we take it to be a Palæocrinoid of low organization.

There are several points in Wetherby's description with which we cannot agree. He describes the mouth or ambulacral orifice as situated nearly centrally upon the upper surface. We had several of Wetherby's best specimens for comparison, but were unable to observe in any of them an external oral orifice, and doubt if such an orifice existed in this Lower Silurian genus "upon the surface." Neither can it be ascertained from the specimens whether there were proximals surrounding the oral plate. Wetherby further speaks of "a valvular anal opening, placed between the upper azygous plate and the mouth," and he mentions "a proboscis or ventral sac" which was said to be "indicated by the presence of the upper azygous plate." If it is meant that the so-called "valvular opening" is separated from the ventral sac, and we infer it from fig. 1 on Plate 5, which shows an irregular break upon the ventral surface in the direction to which he alludes, he is certainly in error. Even if an opening did exist, we doubt if he could have observed small, valvular pieces in specimens in which even the larger ventral plates cannot be distinguished. If he means that the anal opening is connected with the ventral sac, placed along its inner or ventral side, we can partly agree with him.

Wetherby described the genus as having in three of its rays arms like those of the Crinoidea, in the other two rays appressed ambulacra, such as occur in the Cystidea. He does not say anything about the length of the three arms, leaving it in doubt, whether he took the three projections to be only the stumps of the arms, or as representing their full length. He only mentions that the arms are composed of a single row of plates, that they are very deeply excavated at the inner side by the ambulacral furrows, and that the latter are covered by a closely interlocking series of small plates, having the same arrangement as those of the two appressed ambulacra. He mentions further a more or less obscure furrow upon the outer surface, "of which nothing further is known."

Carpenter, in his paper on *Hybocrinus* and *Hybocystites*, called attention to the fact, that in Wetherby's figures, and in the specimens which he had examined himself, only one or two so-called arm joints were shown, that from appearances there had been no others, and that these formed, in all probability, "merely upward prolongations of the radials." He states further that the "more or less obscure furrow," seen by Wetherby upon the outer surface of each arm, was in reality a recurrent ambulacrum, and that in his opinion the relations of *Hybocystites* are rather with the Blastoids and "Crinoids than with the Cystids." Upon the latter point we cannot agree with him, although we admit that there are recurrent ambulacra in all five rays. We think, like Wetherby, that the ambulacra resemble decidedly those of the Cystids, and not those of the Blastoids. *Hybocystites* evidently had no hydrospires and no hydrospire pores, and the ambulacra, contrary to any of the Blastoids, extend beyond the radials down into the basals. Neither has it calicine pores, nor pectinated rhombs, and hence cannot be a Cystid, even if it has appressed ambulacra, which, we think, take the place of true arms.

Among the specimens from the Canada Survey Museum, which we had the good fortune to examine through the kindness of Prof. Whiteaves, we examined the type of *Lecanoçrinus elegans* Billings (*Taxocrinus elegans* W. and Sp.), one of the earliest of all known Crinoids, and which seems to be destined to throw light upon the peculiar ambulacra of *Hybocystites.* This beautiful and well-preserved specimen has upon the outer or dorsal surface of its free arms, upon each one of them, from their tips as far down as the top of the secondary radials, in addition to their regular ventral furrows a recurrent dorsal furrow, such as is found in *Hybocystites* upon the calyx, and dorsally and ventrally upon the two arm joints. These dorsal furrows are indistinctly represented by Billings in Decade iv, Pl. 4, fig. 4 *a*, although in the specimen they are well defined, and it appears as if they had been lined by a double series of alternating plates. Such dorsal furrows have since been identified also in the type of *Taxocrinus lævis* by Walter R. Billings. That these furrows are continued from the ventral side, and as such form a part of the ambulacra, cannot be doubted, and is further proven by the fact that the furrows diminish in width as they descend the surface of the arms. In these species the regular furrows of the arms probably were not sufficient to supply the animal. This was certainly the case in *Hybocystites*, which in two of its rays has no brachial appendages whatever, and these consist in the three other rays of but a few joints, the ambulacra resting almost exclusively against the dorsal side of the calyx.

Hybocystites is one of the earliest and lowest forms of the Palæocrinoidea; it may be regarded as a permanent larval form of *Hybocrinus*, which had no arms, but in their place food grooves upon the dorsal side of the calyx. It is interesting that in this case as in that of *Baerocrinus*, which has similar relations to *Hoplocrinus* as this has to *Hybocrinus*, three of the rays are somewhat higher developed than the two others.

We propose the following:—

Revised Generic Diagnosis.—Hybocystites agrees with *Hybocrinus* in its general form, the arrangement and proportions of the plates in the calyx, in the ventral covering, and in the form and size of the ventral sac, but differs from that genus essentially in the arm structure. It has no underbasals; five large subequal basals, five radials, one of them much smaller and resting upon the right sloping upper side of the large azygous plate. The latter supporting at its left sloping side an anal plate, in form resembling the adjoining small radial. Arms rudimentary, of the most primitive kind, restricted to the two posterior rays and the anterior one. They consist, so far as known, of two quadrangular joints, which are united with the radials by close suture. The joints are provided with an ambulacral furrow, which enters the calyx apparently at the top of the radials as in *Hoplocrinus*. This furrow passes from the ventral side of the two arm joints, over the top of the upper one, and follows the dorsal side of the plates until reaching the calyx, whence it extends upon the surface of the radials to the basals, either entering them or terminating close to the basi-radial suture or along the face of the large azygous plate. The two antero-lateral rays have no arm plates whatever, but each is provided with an ambulacral furrow, passing out from near the top of the radials, traversing these plates, and entering the basals. There is considerable irregularity in their position and length, but as a rule these latter furrows enter deeper into the basals than those of the three other rays. The furrows are provided with two rows of side pieces which are arranged in the usual way.

Ventral sac short, as in *Hybocrinus*, provided along its ventral side with a small anal opening. Column circular, small.

The only known species is:—

1880. **Hybocystites problematicus** Wetherby, Cincin. Journ. Nat. Hist. (July). P. Herb. Carpenter, 1882, Quart. Journ. Geol. Soc. London (Aug.).—Trenton gr. Mercer Co., Ky.

FAMILY XVIII.—HETEROCRINIDÆ Zittel.

(Emend. W. and Sp.)

Zittel and S. A. Miller included among the Heterocrinidæ the genera *Graphiocrinus* and *Erisocrinus*, which both have underbasals, and which differ essentially in the plates of the azygous side. We place in this family only *Heterocrinus*, *Iocrinus* and our new genera *Stenocrinus* and *Ohiocrinus.*

The Heterocrinidæ differ from the Cyathocrinidæ and Poteriocrinidæ in the absence of underbasals, in the arm structure, and the arrangement of their azygous plates.

In 1866, Hall thought he observed in *Heterocrinus* two rings of five pieces beneath the radials, and he adopted the term basals for those of the proximal ring, and that of subradials for those of the succeeding one. Afterwards, it was proved by Meek, Ohio Paleont., i, p. 2, that the so-called "basals"—proximal ring—were not plates of the calyx but parts of the column. He described the stem to be divided longitudinally, and the so-called "basals," which in their vertical range were said to correspond with the five segments of the column, as constituting the imperfectly developed uppermost stem joint. Meek proposed for these plates the name "subbasals," and called those of the next ring basals, while we used on Pt. I of the Revision the terms underbasals and basals, respectively, as we took all of them to be integral parts of the calyx.

We have lately given this subject careful consideration, and found by grinding the column in various species, that important differences exist among the species originally referred to this genus. We found that most of them have a pentapartite column, of which the five sections alternate with the basals without forming a part of the calyx, but that the column of *Heterocrinus simplex*, Hall's typical species, is tripartite, composed of three equal sections.

We have elsewhere shown that whenever the column is divided, its sections alternate with the proximal ring of plates in the calyx. They are placed interradially when those plates are underbasals, radially when they are basals, and as they have in *Heterocrinus* and allied genera a radial position, we may assert that these genera had no underbasals. The Heterocrinidæ occupy, owing to the absence of underbasals, relatively, the same position toward the Cyathocrinidæ and Poteriocrinidæ as the Actinocrinidæ and Platycrinidæ hold toward the Rhodocrinidæ. They agree with the Cyathocrinidæ and Poteriocrinidæ in having the azygous interradius extended into a porous ventral sac.

The arms consist of single joints, are comparatively strong, and either bifurcate or remain simple from above the brachials. The pinnules are given off not from alternate joints, but alternately from each second, third or fourth joint. They are heavy and long, and sometimes bifurcate near their tips. In the typical form of *Heterocrinus* always two joints are connected by syzygy, but we are unable to prove the syzygy in species referred by us to *Stenocrinus* and *Ohiocrinus*, unless by the pinnules which are given off regularly from every third or fourth joint. Most probably in *Iocrinus* and *Stenocrinus* the pinnules, and sometimes even their branches, were developed into regular arms, for the divisions follow each other alternately and at regular intervals, and the branches have no further pinnules.

The Heterocrinidæ agree with the Hybocrinidæ in the absence of underbasals, but differ essentially in the proportions of the calyx and ventral sac. In the former the calyx is extremely small, the ventral tube large; in the Hybocrinidæ, on the contrary, the calyx comparatively large and the sac small. They also differ in the structure of the arms, which in the Heterocrinidæ are more highly developed.

The structure of the ventral side has been observed only in "*Heterocrinus juvenis*," where it is composed of five comparatively large plates, which enclose a small oral plate. The ventral sac throughout the whole family is much stronger than in the Hybocrinidæ, reaching sometimes the tips of the arms, and it is profusely perforated.

Position, *Locality*, *etc.*—Confined to the Lower Silurian of America. The Heterocrinidæ, although forming a neat little group by themselves, may be considered as the forerunners of several types which afterwards became distinct families. *Heterocrinus* foreshadows the Belemnocrinidæ, *Iocrinus* the Poteriocrinidæ, while *Anomalocrinus* is a prophetic type for the Cyathocrinidæ.

1. HETEROCRINUS Hall (not Frass).

(Restricted and redefined by W. and Sp.)

1879. Revision Palæocr., Pt. i, p. 68.
1880. Wetherby, Cincin. Journ. Nat. Hist., July number.
1881. Wetherby, ibid., April number.

Heterocrinus, as defined by Hall and revised by Meek, contains so widely different species that a subdivision becomes necessary. This has been conceded by previous writers. Wetherby, in describing his *H. Milleri*, expressed the opinion that in the comparative size of the column, and in the plates of the calyx, that species differed sufficiently from *Heterocrinus simplex* to be separated at least subgenerically. And a year later, he directed attention to his *H. Vaupeli*, which he thought to be very distinct in the structure of its arms. *H. Vaupeli*, if it is a good species, which we doubt, agrees in its arms and pinnules closely with *H. constrictus* and *H. laxus*, with either of which it may be identical, but not with *H. simplex*, as suggested by S. A. Miller. The species heretofore referred to *Heterocrinus* vary in the composition of their radials, in the structure of arms and pinnules, and in the column. *Heterocrinus simplex*, Hall's type, has five basals of varying form, owing to irregularities in the radials. The radials in two of the rays consist of a large single plate, two others are divided into two sections, and the fifth one rests upon the azygous plate, which agrees in size with the lower half of the compound radials. The compound plates consist of two pieces each, which together, agree closely in form and size with the two single plates. The brachials are large; they consist of two nearly equal plates, united by syzygy, and support ten heavy, simple arms. The arms, to their full length, are composed of syzygial joints, which, as we think, were connected by suture and not by articulation. The epizygal or pinnule-bearing pieces are slightly wedge-shaped, and alternate with one another; the lower or hypozygal ones rhomboidal, and their upper and lower sides are parallel. Pinnules stout and comparatively long.

All other species heretofore referred to this genus, with the exception of *H. canadensis*, which may be identical with *H. simplex*, have a somewhat different arm structure. Not only are the pinnules given off at greater intervals, but they attain the size and form of arms or armlets, which sometimes branch again, and extend to the general height of the primary arms. The latter agree also in having a strictly pentagonal and pentapartite column, contrary to *H. simplex*, in which the column is stouter, almost circular, and regularly tripartite. The species with a quinque-partite column are divisible again into two groups, the one with a straight, comparatively small ventral tube, the other in which the tube is thread-like, convoluted, and even in its coiled state extending beyond the limits of the arms. We hold these differences important enough to make them the basis for another separation, proposing for the latter the genus *Ohiocrinus*, with *H. laxus* Hall = *Ohiocrinus laxus* as type, and for the other the genus *Stenocrinus* with *H. heterodactylus* Hall = *Stenocrinus heterodactylus* as type.

Heterocrinus inæqualis and *H. articulosus* Billings have been referred by us to *Calceocrinus; H. crassus* and *subcrassus* to *Iocrinus.*

The genus *Heterocrinus* thus restricted may be defined as follows :—

Revised Diagnosis.—Calyx small; subcylindrical; tapering but slightly from the column upwards.

Basals five, more or less unequal, without underbasals; the so-called subbasals of Meek representing the upper stem joint.

Radials very irregular, and varying among the rays in number as well as in size. There are two segments in the two antero-lateral rays, while the three remaining rays have but one, this, however, nearly as large as the two in the other rays. The two plates at the right postero-lateral side consist of the azygous piece—the lower one—and of the radial, which upon its upper side supports the brachials, giving off laterally a small ventral tube. Arms ten, composed of single joints, alternately united by syzygy, with strong pinnules from every second joint.

Column tripartite, almost circular; axial canal large, pentalobate, the lobes directed interradially.

Locality, *Position*, *etc.*—Trenton and Hudson River group of America.

1859. **Heterocrinus canadensis** Billings, Geol. Rep. Can., Decade iv, p. 48, Pl. 4, fig. 5.—Trenton limest. Ottawa and Montreal, Canada.

1843. **H. simplex** Hall, Geol. Repr. N. York, vol. i, p. 280, Pl. 76, figs. 2 a–d; also Geol. Surv. Ohio, Paleont. i, p. 7, Pl. 1, figs. 4 a–c, 5 a–b, 6 a–b.—Hudson River gr. Cincinnati, Ohio.

*1873. **H. grandis** Meek, described as **H. simplex** var. **grandis**, Geol. Surv. Ohio, Paleont. i, p. 9, Pl. 1, fig. 6, and figured by Hall as **H. simplex** in the 24th Rep. N. Y. State Mus. Nat. Hist. Pl. 3, fig. 11.—Hudson River gr. Cincinnati, Ohio. **H. grandis** occurs at a higher horizon, is more robust and has shorter arm joints than **H. simplex.**

STENOCRINUS, nov. gen.

(Syn. *Heterocrinus* in part).

(*στενόσ*, narrow ; *κρίνον*, a lily).

Generic Diagnosis.—General form subcylindrical; calyx small; arms long.

Basals five; of a more regular form than in *Heterocrinus*, angular at their superior margins. They form a cup, which spreads but little from the column upwards.

Radials irregular, consisting of one or two plates; two of the rays—sometimes three—being composed of two segments each, the others of only one. The single plates are almost as large as any of the compound ones. Only four of the radials supported upon the basals; the fifth one smaller, resting upon the truncate upper side of the azygous plate, and occupying toward the latter a similar position as the two sections of the compound radials toward each other. The smaller radial is transversely pentagonal, and resembles in outline a bifurcating plate. It supports upon its sloping right side the brachials; toward the left the ventral sac as in *Iocrinus.* Brachials generally four to each ray, the upper one axillary, and supporting the two main arms, which sometimes branch again, and give off at regular intervals, from alternate sides, strong, arm-like pinnules. All arm joints which have no pinnules are strictly quadrangular, while the pinnule-bearing joints have almost the form of bifurcating plates.

Axygous plate pentagonal, shorter than adjoining radials. Ventral tube, near the base composed of quadrangular, heavy plates, generally longer and narrower than the brachials. The structure of the tube in its upper portions not known. The plates of the ventral side have been observed only in *H. juvenis*, in which they are composed of five comparatively large interradial pieces, enclosing a small oral plate as in *Haplocrinus.* Column large, pentagonal, pentapartite, the sutures directed interradially, giving to the segments a radial position. Axial canal large, pentagonal; angles interradial.[1]

Geological Position, etc.—*Stenocrinus* is known only from the Silurian of America.

We refer to *Stenocrinus* the following species, all previously described under *Heterocrinus*, and noted under that genus in Rev. I, p. 70 :—

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[1] The columnar canal of *Stenocrinus* is correctly represented in fig. 12 of Pl. vi, not, however, in fig. 13, in which the rays should be directed interradially.

> *__Stenocrinus heterodactylus__, the type of the genus, and its variety *propinquus;* *__S. exilis__ Hall (not Meek); *__S. juvenis__; *__S. Milleri__, and perhaps __Heterocrinus tenuis__ Billings.

To these we add :—

*1883. **Stenocr. bellvillensis** (W. R. Billings), **Heterocr. bellvillensis,** Ottawa Field Naturalist's Club, Trans. No. 4, p. 49 with plate.—Trenton limest. Bellville, Ont.

*(?) 1879. **S. geniculatus** (Ulrich), **Heterocr. geniculatus,** Journ. Cincin. Soc. Nat. Hist. (April), Pl. 7, fig. 13.—Utica Shale. Cincinnati, Ohio. This species differs too much from the other species to be left under **Stenocrinus,** but the only specimen which we examined was not sufficiently perfect to warrant a satisfactory generic description.

*1882. **S. pentagonus** (Ulrich), **Heterocr. pentagonus,** Journ. Cincin. Soc. Nat. Hist., p. 176, Pl. 5, figs. 10, 10 *a*.—Hudson River gr. Cincinnati, Ohio.

OHIOCRINUS, nov. gen.

(*Heterocrinus* Hall, in part.)

This form is closely allied to *Stenocrinus*, but differs from that in two points: the form of its arm appendages, and in the construction of its ventral sac.

The plates of the calyx are arranged as in *Stenocrinus*, and also the column is strong, pentangular and pentapartite. The arms, which are ten, do not bifurcate, and are provided with stout pinnules, given off alternately from every fourth or fifth plate. The pinnules are long, bifurcating, and extend to the tips of the arms.

The ventral tube rests upon the left sloping side of the right posterior radial; it ascends spirally, and in such a manner that adjoining convolutions touch each other, being perhaps suturally connected. It is composed of numerous hexagonal pieces, arranged alternately, and in longitudinal rows.

Column strong; indistinctly pentangular; pentapartite. The older stem joints are rather long pieces which have a well-marked pentapetaloid concavity upon their articular faces. The younger joints consist of five small convex leaflets, disconnected laterally, which fill the concavity of the older joints, exposing to view along the lateral face of the column a small trigonal piece. A similar, if not the same, columnar structure is found in *Stenocrinus*.[1]

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[1] *Ohiocrinus* resembles *Stenocrinus* very closely, and can only be upheld by the form of the ventral tube. We never saw the appendage of *Stenocrinus*, but Mr. S. A. Miller claims it to be distinct, and this induced us to make the separation.

Geological Position, etc.—Restricted to the Lower Silurian of America.

We place in this genus the following species:

*1866. **Ohiocrinus constrictus** (Hall), **Heterocrinus constrictus,** 24th Rep. N. Y. St. Cab. Nat. Hist., p. 210; also Geol. Surv. Ohio, Paleont., vol. i, p. 3, Pl. i, figs. 10 *a b*; W. & Sp., Rev. I, p. 15.—Hudson River gr. Cincinnati, Ohio.

*1866. **O. laxus** (Hall).—Type of the genus.—**Heterocrinus laxus,** 24th Rep. N. Y. St. Cab. Nat. Hist., p. 211, pl. 5, fig. 15; also Geol. Surv. Ohio, Paleont., vol. i, p. 14, Pl. i, figs. 8 *a b*.—W. & Sp., Rev., I, p. 70.—Hudson River gr. Cincinnati, Ohio.

*1882. **O. œhanus** (Ulrich), **Heterocr. (Iocrinus) œhanus,** Journ. Cincin. Soc. Nat. Hist., vol. v, p. 175, Pl. 5, fig. 9.—S. A. Miller, 1883, **Heterocr. œhanus,** Cat. Amer. Palæoz. Foss. (Edit. ii), p. 283.—Hudson River gr. Cincinnati, Ohio.

IOCRINUS Hall.

1879. Revision of the Palæocr., Pt. I, p. 70.
1882. P. Herb. Carpenter, Quart. Journ. Geol. Soc. London, p. 306.
1883. W. & Sp., Amer. Journ. Sci., vol. xxvi (Novbr.), pp. 370, 376.

The genus *Iocrinus* must be slightly modified, as stated in our recent notes "on *Hybocrinus*, *Baerocrinus* and *Hoplocrinus*." In that paper, to which we refer for further particulars, we gave at some length the reasons which impelled us to regard the large plate, which we had formerly called a radial, as representing the azygous plate, and the smaller pentangular plate above, as the right posterior radial.

Walcott discovered lately a new generic form, for which he proposed the name *Merocrinus*. It agrees with *Iocrinus* in the structure of the azygous side, and would probably be identical with that genus if it had not well-developed underbasals. That underbasals are entirely absent in *Iocrinus* is plainly shown by its strictly pentagonal column, in which the angles have a radial position.

Revised Diagnosis.—Dorsal cup broadly spreading and perfectly symmetrical to the top of the second circlet of plates; it is short, and resembles an inverted pentagonal pyramid with the five sides deeply concave.

Basals small, nearly equal. Radials five, four of them of equal form and height, comparatively large, strong and pentagonal; their upper sides truncated throughout their entire width for the reception of the brachials. Adjoining these radials, in the same ring, is the azygous plate, which has not only the form but general appearance of the four radials. It supports upon its truncate upper side the fifth radial, that of the right posterior ray. The latter, which resembles in form a large bifurcating plate, supports upon its right upper side the brachials, and toward the left the first plate of the anal tube, being thus a radial, but partly with interradial functions. The radials in all five rays are followed by five to six brachials, the upper one bifurcating, the others quadrangular, all wider than long, and those of adjoining rays meeting laterally. These are succeeded by the regular arm plates.

Arms long, gradually tapering to the tips; bifurcating at regular intervals, and most of their branches bifurcating once or twice again; each division extending to the general height of the arms. Arm joints quadrangular, resembling those of the brachials, but somewhat narrower.

The ventral sac, at its posterior side, consists of a single row of rather large and strong plates, extending up to the full length of the sac, and forming all the way up a keel-like projection. In general appearance, these plates, which rest against the sloping side of a radial, resemble the brachials and arm plates, although they are somewhat higher and not as wide. Both sides of the ridge-like projection are indented for the reception of other plates. At each side there are two pieces connected to each median plate, one abutting against the middle part, and the other placed opposite the suture. These plates are very short and wide, longitudinally arranged; they are curved so as to form a deep transverse groove, their lower sides turned up and forming a transverse ridge. The plates do not meet horizontally, but have a narrow open space at the top of the ridge, which in perfect specimens is covered by a row of minute pieces, apparently with a pore or small opening at the place of juncture with the larger plates. The sac is composed of five rows of these plates, which are connected laterally by a straight suture all the way up.

Column strong, sharply pentagonal, its angles in a line with the radial plates.

We add the following species to our former list:—

1883. **Iocrinus trentonensis** Walcott, Adv. sheets of 35th Rep. N. Y. St. Cab. Nat. Hist., p. 4, Pl. 17, figs. 7, 8.—Trenton limest. Trenton Falls, N. Y.

FAMILY XIX.—ANOMALOCRINIDÆ W. and Sp.

ANOMALOCRINUS Meek and Worthen.

1879. Revision Palæocr., Pt. i, p. 72.
1879. S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (Decbr., p. 6).
1882. S. A. Miller, ibid. (April, p. 14).

This genus differs from the Heterocrinidæ in the form of the calyx, which is depressed and not obconical, and in the arrangement of the pinnules. It agrees with them in the plates at the azygous side, which we misunderstood in our former description, and this renders a redescription necessary, which we substitute in place of our former one.

Revised Diagnosis.—General form depressed, calyx comparatively large, rather shallow, subglobose; arrangement of plates extremely irregular, scarcely two plates being of equal size.

Basals five, small, subequal, partly hidden by the column.

Radials irregular, all differing in size and form; simple or compound; sometimes divided vertically. The left antero-lateral radial is compound, composed of two pieces; that of the opposite side and the anterior radial are simple. The left postero-lateral radial is the largest plate in the calyx, and either simple or bisected vertically, composed of two nearly equal parts. The lower segment of the left antero-lateral radial is subquadrangular, the angle along the basi-radial suture being so obtuse as to form almost a straight line; upper side truncate and slightly convex. The upper segment is irregularly hexagonal, truncate above and below, much wider at the lower than at the upper side, widest across the lateral angles. The two together have almost the dimensions of the single radials, but, in place of being wider than high, they are higher than wide, with a narrow concavity for the reception of the brachials. The fifth radial—the right postero-lateral one—rests against the truncate upper side of a large azygous plate, and as this stands in line with, and has nearly form and proportions of the lower section of the compound radial, and the radial plate the form of its upper segment, the two appear in the specimen as if forming jointly another compound radial. (See Diagr. Rev. i, Pl. ii).

There is also among the rays a great diversity in the number of brachials, and this gives to the specimen that abnormal, irregular outline which is so characteristic of the genus. Some of the rays have two, others three brachials, while the right posterior ray has generally four or more.

Arms long; bifurcating at regular intervals; widely divergent, rather stout at their origin; tapering upward. They are composed of a succession of rather long, quadrangular pieces, interrupted only by the axillaries which are pentangular, and which divide the main arm, and each division of the arm, into two equal parts. The pinnules are slender, composed of long pieces, given off from every arm joint, but at one side only in succession—not alternately—until the next bifurcation of the arm, when on both divisions they all change to the opposite side. By this arrangement there are always 8 to 10 pinnules in succession, first on one side, then on the other. The first pinnule occurs on the second arm plate, not on the first, but every succeeding plate is pinnulated with the exception of the bifurcating ones. The proximal pinnule after each bifurcation is considerably heavier and longer, almost arm-like, and bifurcating, the others are simple. The arm furrows are shallow but wide, only one side having sockets for the reception of pinnules.[1]

The ventral sac is tubular, and rests upon the left side of the posterior radial as in the Heterocrinidæ. The proximal plate of the tube is large, subquadrangular, and is succeeded by other apparently large pieces. Of the plates at the ventral side little is known. S. A. Miller mentions two rows of small pieces near the ventral tube, but, as nothing is known as to their arrangement, they may be covering plates.

Column very large, almost circular, pentapartite, highly ornamented; central canal large, star-shaped, the projections located interradially. The structure of the column along the axial canal resembles that of *Barycrinus* and *Vasocrinus*, with which *Anomalocrinus* agrees also in the form of the calyx.

Geological Position, etc.—Lower Silurian of America. The only known species are: *Anomalocrinus caponiformis* Lyon, and *A. incurvus* Meek and Worthen, which have been previously noted.

FAMILY XX.—BELEMNOCRINIDÆ S. A. Miller.

S. A. Miller has proposed for the genus *Belemnocrinus* a separate family, in which we fully agree. It cannot be placed in any of the other groups, without depriving them of their best distinctive characters. It forms a link between *Heterocrinidæ* and *Cyathocrinidæ*, resembling the former in the absence of underbasals and in the arm-structure, the *Cyathocrinidæ* in the arrangement of plates at the azygous side and of the ventral tube. As the most characteristic features we mention the extremely small visceral cavity, in which the genus resembles *Apiocrinus* of the *Neocrinoidea;* the comparatively large size of the basals; the absence of underbasals; the position of the azygous plate in line with the five radials; the large porous ventral tube, and the condition of the pinnules, which are given off regularly at certain intervals, not alternately from every joint.

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[1] Our descriptions of arms and pinnules in this interesting genus were made from a most beautiful specimen in the collection of J. H. Harris, Esq., of Waynesville, O., who had the kindness to send it to us for description.

Belemnocrinus was referred by White to the *Cyathocrinidæ*, and he described the calyx to be composed of three rings of plates. We have shown in 1877 that the part which he took to be the "basals" is the upper stem-joint, and that the dorsal cup consists of only two rings of plates. We further directed attention to the affinities between *Belemnocrinus* and the recent genus *Rhizocrinus*, which had been pointed out also by Pourtales, in the Memoirs of the Museum of Comp. Zoology, vol. iv, No. 9, p. 29. The construction of the dorsal cup in the two genera is very similar, however, in *Rhizocrinus*, the sutures between the basals are fused together; while in *Belemnocrinus* they are plainly visible, and the former has no anal plate and no ventral sac.

Belemnocrinus was placed by Zittel among the *Poteriocrinidæ*, although it has neither the arm structure nor the pinnules of that family, nor the azygous plate, and not even underbasals.

The name *Belemnocrinus* was used in 1876 by Munier-Chalmes (Jour. Conch., Ser. 3, vol. xvi, p. 102) for certain basal plates, evidently of a Blastoid, and changed by Oehlert to *Belocrinus*, 1882 (Extr. du Bull. Soc. Géol. de France, Ser, 3, p. 362).

BELEMNOCRINUS White.

(Pl. 5, figs. 10 and 11.)

1862. White, Proc. Bost. Soc. Nat. Hist., vol. ix, p. 14.
1866. Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 251.
1868. Meek and Worthen, Geol. Rep. Illinois, iii, p. 463.
1877. W. and Sp., Amer. Jour. Sci. (April), p. 253.
1879. Zittel, Handbuch der Palæont., i, p. 362.
(Not *Belemnocrinus* Mun.-Chalmes = *Belocrinus* Oehlert.)

Generic Diagnosis.—Dorsal cup small, narrow, sometimes almost tubular.

Basals five, very large, long, narrow, of somewhat irregular shape, forming an ovoid to cylindrical cup. The cup is nearly solid, having only a small central canal, and a shallow subconical excavation at its upper end, the latter forming a part of the visceral cavity.

Radials five, always smaller than the basals, enclosing an anal plate. They are subquadrangular, slightly excavated at their upper side, and support four (exceptionally five) brachials, of which the upper one is bifurcating and gives off the arms. Arms two to each ray, simple throughout, composed of compound joints, with one or two syzygies in each joint; the upper segment giving off a strong pinnule. The oblique upper faces of the epizygal or pinnules-bearing joints are arranged alternately, and this gives to the arms a strongly waving, zigzag outline. At the extremities of the arm the pinnules are generally given off from every joint. Pinnules long, arm-like, bifurcating once or twice, like arms. With the arms the pinnules also correspond in length, all of them extending to the same height.

Anal plate resting between two of the radials and upon one of the basals. This plate, which resembles the radials in form, supports a large ventral sac, composed of numerous hexagonal plates, alternately arranged, with slit-like openings along their lateral edges, which meet with corresponding slits in the adjoining plates.

Other parts of the ventral side unknown. Column with or without lateral cirrhi; more or less sharply pentangular, the outer angles radial, the rays of the central canal and the columnar cirrhi directed interradially.

Geological Position, etc.—Known only from the two divisions of the Burlington limestone.

1877. **Belemnocrinus florifer** W. and Sp., Amer. Journ. Sci. (Ser. 3), Vol. xiii, p. 256.—Upper Burlington limestone. Burlington, Ia.

1877. **B. Pourtalesi** W. and Sp., Amer. Journ. Sci. (Ser. 3), Vol. xiii, p. 258.—Lower Burlington limest. Burlington, Iowa.

1862. **B. typus** White (type of the genus), Proc. Bost. Soc. Nat. Hist., Vol. ix, p. 14.—W. and Sp , 1877, Amer. Journ. Sci. (Ser. 3), Vol. xiii, p. 254.—Upper Burlington limest. Burlington, Iowa.

1866. **B. Whitei** Meek and Worthen, Acad. Nat. Sci. Phila., p. 251; also Geol. Rep. Illinois, iii, p. 463, Pl. 18, figs. 4 *a*, *b*, *c*.—Lower Burlington limest. Burlington, Iowa.

(?) HOLOCRINUS W. and Sp.

(ὅλος solid, κρίνον a lily.)

The above name is proposed to include a species which was lately described from rather imperfect specimens by Mr. Picard, under the name of *Encrinus Beyrichi*; but which certainly is no *Encrinus*. We entertain little doubt that the species must be referred to the Belemnocrinidæ; we are, however, not quite so sure that it is generically distinct from the typical form, which depends upon the presence or absence of the anal plate. No anal plate has been described in this species, and it is more than probable that none was present. It perhaps represents one of those transition forms, which in their earlier life were good Palæocrinoids, but by resorption of the interradial plates attained, to some extent, the characteristics of the earlier Neocrinoidea.

Generic Diagnosis.[1]—Dorsal cup strictly pentahedral; constricted above the basals. Basals large, forming an almost solid subglobular body, without underbasals. Radials very small, quadrangular, supporting three to four narrow brachials, the upper one bifurcating. There are two arms to each ray which remain simple. Arms thin, composed of short, cuneate joints, with rather stout pinnules.

Column pentangular, and, as in *Belemnocrinus florifer*, provided with long cirrhi, given off at intervals in whorls from the nodal joints, and extending up, and partly covering, the calyx and the lower portions of the arms.

The only known species is:

*1884. **Holocrinus Beyrichi** (Picard), W. and Sp., Zeitschr. d. Deutsch. geolog. Gesellsch., Jahrg. 1883.—Muschelkalk. Sondershausen, Germ.

FAMILY XXI.—CYATHOCRINIDÆ Roemer.

(Emended Zittel, emended W. and Sp.)

a. DENDROCRINITES.

MEROCRINUS Walcott.

1883. Adv. sheet 35th Rep. N. Y. State Cab. Nat. Hist., p. 2.

In the arrangement of the plates at the azygous side and in the construction of its ventral tube, this genus has close affinities with the Heterocrinidæ, but differs from them in having underbasals. In addition to Walcott's typical species, we refer to *Merocrinus: Dendrocrinus curtus* Ulrich.

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[1] Our diagnosis is made from the figure of Mr. Picard's imperfect specimen.

Generic Diagnosis.—Dorsal cup very small; short and extending laterally but little beyond the periphery of the upper stem joint.

Underbasals five, comparatively large, seen distinctly in a side view. Basals short, all hexagonal; alternating with four of the radials and the azygous plate, which all are of similar form, pentangular, wider than long. The four radials support upon their truncate upper face a row of brachials, the azygous plate from the same level the fifth radial. The right posterior radial has the same form as the azygous plate, but, while the latter is angular below, the radial has an angular upper side, giving off toward the left the ventral tube, and toward the right a row of brachials. There are generally six or more brachials to each ray, composed of short quadrangular pieces, except the upper which is axillary. Arms long, bifurcating; without pinnules; tapering toward the tips; composed of quadrangular joints. The bifurcations take place at regular intervals, and both arms of the same division are of equal size.

Column round, very strong, composed of unusually narrow joints.

Locality, Position, etc.—Lower Silurian of America.

*1879. **Merocrinus curtus** (Ulrich), **Dendrocrinus curtus**, Cincin. Soc. Nat. Hist., vol. ii (April), Pl. 7, fig. 14.—Utica shale. Cincin., O.
1883. **M. corroboratus** Walcott, Adv. sheet 35th Rep. N. Y. St. Cab. Nat. Hist., p. 4, Pl. 17, fig. 6.—Trenton limest. Trenton Falls, N. Y.
1883. **M. typus** Walcott, *Ibid.*, p. 3, Pl. 17, fig. 5.—Trenton limest. Trenton Falls, N. Y.

CARABOCRINUS E. Billings.

(Revised by W. and Sp.)

1856. E. Billings, Rep. Geol. Surv. Canada, p. 275.
1859. E. Billings, *Ibid.*, Decade iv, p. 30.
1879. W. and Sp. Revision I, p. 143.
1881. Walter R. Billings, Trans. Ottawa Field Natur. Club, p. 34.

In Part I of this Revision we placed *Carabocrinus* among the doubtful genera. It was founded by E. Billings upon certain peculiarities among plates of the azygous side, resembling otherwise closely *Cyathocrinus*. When Billings proposed the genus, the azygous side had been observed only in a single specimen, and as the plates were arranged very differently from those of other genera, we suspected that the type specimen was a malformed or recuperated *Cyathocrinus.* This view, however, must be given up, since other specimens have been found which show the plates under similar conditions. Mr. Walter R. Billings informed us, in 1880, of the discovery of two more specimens in which the azygous plates were arranged as in E. Billings' type. These specimens were afterwards noticed by him in the Transactions of the Ottawa Field Naturalist's Club of 1881, p. 35.

Carabocrinus was described by E. Billings—using our terminology—to be constructed of five underbasals, four of them pentagonal, the fifth hexagonal; five basals, three of them hexagonal, one heptagonal and one pentagonal, the latter smaller than the others; of five radials; three azygous plates, one of them supported upon the hexagonal underbasal, a second upon the small pentagonal basal, the third between two radials. Consulting the generic diagram, Decade iv, p. 30, we find that the small, pentagonal basal (subradial plate of Billings) has scarcely half the size of the other basals, and the first azygous plate is placed at its left side, contrary to all other Cyathocrinidæ. This structure seemed to us so improbable that before accepting it we applied to Prof. Whiteaves of the Canada Survey Museum for the type specimen. We now found that in Billings' diagram the plate in question is represented considerably larger than it is in the specimen, the so-called "azygous plate," to the left of the former, smaller, that the basals at their lower sides form in the specimen a much more obtuse angle, almost a straight line, and that the underbasals are comparatively smaller.

From our diagram it will be seen, that the second or basal ring really consists of six plates, four of them equal, the fifth one nearly as high but somewhat narrower, the sixth subquadrangular, small, not more than half the size of the former. That the latter piece which is united with the azygous plate by a horizontal suture is a basal—subradial of Billings—seems to us exceedingly doubtful, the more as the adjoining plate meets all the requirements of a basal. This plate, which Billings called the first azygous piece, and which we take to be the posterior basal in conformity with other Cyathocrinidæ, has an azygous plate at its right side, and this supports with its right upper sloping side a special anal plate. The small plate within the basal ring, which is only known in this genus, is, we think, a supplementary azygous plate of no fundamental importance, a plate bearing to the regular azygous plate similar relations as the small accessory interradials in some specimens of *Archæocrinus sculptus* to the regular interradials.

We offer the following :—

Revised Generic Diagnosis.—Underbasals five, of variable form and size; four of them quadrangular, but only three equal; the fourth one, that facing the azygous side, narrower; the fifth pentagonal, truncate above. *Carabocrinus* is closely allied to *Dendocrinus* and *Homocrinus*, but differs from both in the number and arrangement of its azygous plates.

Basals five, four of them hexagonal; the one toward the right of the azygous plates heptagonal; that on the left side somewhat smaller, truncate below, and occupying the full width of the upper side of the pentagonal underbasal.

Radials heptagonal, the upper side excavated for the reception of the brachials, which occupy about one-third the width of the plate. The brachials, so far as known, consist of two or sometimes three pieces, the upper one sharply wedgeform. Arms, compared with the size of the calyx, remarkably short; composed of quadrangular joints with parallel sutures; bifurcating; tapering gradually to their tips. The branching is similar to that of *Cyathocrinus*, and the arms throughout, as in that genus, are devoid of pinnules.

Plates at the azygous side three. A supplementary azygous plate rests between the basals and extends to half their height. The regular azygous plate is placed between the upper lateral portions of the five basals, and upon the supplementary piece; supporting with its left upper side the anal plate, with its right side the right postero-lateral radial. The anal plate resembles the radials in form and proportion, but its upper face is irregularly convex, and is bordered by a row of small pieces which form a part of the ventral tube.

Column comparatively small, obscurely pentangular, with a large, sharply pentagonal canal. The column is quinquepartite, the sutures arranged alternately with those of the underbasals.

Locality, *Position*, *etc.*—Known only from the Trenton limestone of Canada, but we found detached plates, apparently of this genus, in rocks of the same age near Knoxville, Tenn.

The following species have been described :—

1856. **Carabocrinus radiatus** Billings. Type of the genus, Geol. Surv. Canada, p. 276; also 1859, ibid. Decade iv, p. 30, Pl. 2, figs. 3 a–c; also W. and Sp., Revision i, p. 144.—Trenton limest. Ottawa, Can.

1859. (?) **C. tuberculatus** Billings, Geol. Surv. Can., Decade iv, p. 33, Pl. 10, figs. 2 a–c.—Hudson River. gr. Island of Anticosti.

1859. **C. Van Courtlandti** Billings, Geol. Surv. Can., Decade iv, p. 32, Pl. 2, fig. 4.—Trenton limest. Township of McNab, Can.

EUSPIROCRINUS Angl., Rev. I, p. 143.

AMPHERISTOCRINUS Hall.

1882. 11th Geol. Rep. Indiana of 1881 by Collett, p. 278.

This is one of the few genera of the *Cyathocrinidæ* which have only three underbasals, and this distinguishes it readily from *Homocrinus*, with which it agrees in the plates of the azygous side.

Generic Diagnosis.—Underbasals three, two equal and with truncate upper sides; the third one-half smaller, angular above. Basals five; two of them resting entirely upon the two large underbasals; pentagonal; the two alternating with them hexagonal; the posterior one, which has a truncate upper side, heptagonal. The latter is larger and supports toward the right a pentangular azygous plate; at its truncate upper side a large anal piece; along the left side a radial. The azygous plate is followed by the anal plate, which is laterally connected with the right posterior radial. The radials are pentagonal, with a small semicircular excavation for the reception of the arms. Only one brachial is known, which is quadrangular and extremely small. All other parts are unknown.

The only known species is:—

1882. **Ampheristocrinus typus** Hall, 11th Ann. Geol. Rep. Indiana by Collett, p. 278, Pl. 15, figs. 17–18.—Niagara gr. Waldron, Indiana.

DENDROCRINUS Hall, Rev. I, p. 75.

The following species must be added to our list:—

*1856. **Dendrocrinus angulatus** (Billings), **Palæocrinus angulatus**, Geol. Surv. Canada, p. 269; also Decade IV, Pl. 3, figs. 6 *a b*.—**Cyathocrinus angulatus**, Rev. I, p. 85.—Trenton limestone. Ottawa, Canada.—In examining the type-specimen in the Canada Survey Museum, we found it to be a good **Dendrocrinus**. Toward the right of the basals, underneath the postero-lateral radial, it has a good-sized azygous plate, which at its left sloping upper side supports an anal piece, exactly as in **Dendrocrinus**. The species has a strong ventral tube, of which only the transverse section is seen.

1881. **D. erraticus** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (December), 1881.—Hudson River group. Cincinnati, Ohio.

1880. **D. navigiolum** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (October), p. 4, Pl. 7, figs. 5, 5 *a*.—Utica slate. Cincinnati, Ohio.

1883. **D. retractilis** Walcott, 35th Rep. N. Y. St. Mus. Nat. Hist. (Extr. p. 5), Pl. 17, fig. 4.—Trenton limest. Trenton Falls, N. Y.

HOMOCRINUS Hall, Rev. I, p. 77.

This genus has been lately so often confounded with *Poteriocrinus*, that for better information, we point out their distinctive characters. *Homocrinus* differs from *Poteriocrinus* in the more slender form of the calyx, in having no plates of the ventral tube within the line of the first radials, in being provided with horseshoe-shaped articular facets, pierced by a round dorsal canal, and in having at least three brachials. Contrary to *Poteriocrinus*, the arms are not pinnulated, and they are composed of quadrangular joints with parallel lines of union. Its relations are much closer with *Parisocrinus*, which, however, has no separate dorsal canal, and the first plate of the tube rests within the calyx.

We add the following species :—

*1879. **Homocrinus ancilla** (Hall), **Dendrocrinus ancilla,** Trans. Albany Inst., vol. x (Abstr. p. 9); also 11th Geol. Rep. Indiana by Collett, p. 271, Pl. 15, fig. 19.—Niagara gr. Waldron, Indiana.

*1858. **H. curtus** (Müller), **Poteriocrinus curtus,** Verh. d. naturh. Verein f. Rheinlande xii, p. 80, Pl. 10, figs. 2–3; also Neue Echinod. Eifl. Kalk., p. 230, Pl. 2, fig. 3.—Schultze, 1866, Echin. Eifl. Kalk., p. 46, Pl. 5.—W. and Sp., **Parisocrinus curtus,** Rev. i, p. 115.—Devonian. Eifel, Germany.

*1882. **H. davisanus** (S. A. Miller), **Poteriocrinus davisanus,** Journ. Cincin. Soc. Nat. Hist., p. 226, Pl. 9, figs. 4, 4 a–b.—Upper Helderberg gr. Deputy, Indiana.

*1882. **H. nettelrothanus** (S. A. Miller), **Peteriocrinus nettelrothanus,** Journ. Cincin. Soc. Nat. Hist., p. 227, Pl. 9, figs. 5, 5 a.—Upper Helderberg gr. Deputy, Indiana.

*1876. **H. nucleus** (Hall), **Dendrocrinus nucleus,** 1st Edit. 28th Rep. N. Y. St. Mus. Nat. Hist., Pl. 15, figs. 7–9.—**Cyathocrinus nucleus,** 2d Edit. ibid., p. 136.—Niagara gr. Waldron, Indiana. The arrangement of the plates at the azygous interradius are not like in **Cyathocrinus** as Hall suggested, but exactly like in **Homocrinus.**

*1863. **H. polyxo** (Hall), **Cyathocrinus polyxo,** New Sp. Foss. Niagara group, p. 5; 28th Rep. N. Y. St. Cab. Nat. Hist. 1st Edit., Pl. 15, figs. 10–17.—Ibid. 2d Edit. p. 135; also W. and Sp., Rev. i, p. 87; 11th Rep. Indiana by Collett, 1882, p. 264, Pl. 14, figs. 10–17.—Niagara gr. Waldron, Indiana.

PARISOCRINUS W. and Sp., Rev. i, p. 115.

Closely allied to *Homocrinus* is *Parisocrinus*, which we made a subsection of *Poteriocrinus.* In doing so, we were not aware that this form is devoid of pinnules. In our descriptions we only pointed out the great resemblance which it has to *Cyathocrinus*, especially in the branching of the arms, but finding the azygous side constructed as in *Poteriocrinus*, we placed it with that genus. More perfect specimens which have since been discovered leave not the least doubt that it is very distinct from *Poteriocrinus*, and a true Cyathocrinoid.

Revised Generic Diagnosis.—General form turbinate. Underbasals large, equal. Basals five, three of them hexagonal; the two connecting with the azygous side heptagonal. The radials are rarely larger than the basals ; four of them are equal, the fifth one has an additional side for the reception of the lower plate of the ventral tube. Articular face horseshoe-shaped, supporting a row of three brachials, of which the upper one is axillary. Arms composed of long slender joints, branching like those of *Cyathocrinus* and without pinnules. The azygous side is arranged as in *Poteriocrinus*, with three plates in the calyx. Ventral tube long, cylindrical, composed of alternately arranged rows of hexagonal pieces, with a pore at each angle. Column round.

Geological Position, etc. — Subcarboniferous. America and England.

We place here *Parisocrinus intermedius*, *P. nereus*, *P. perplexus*, *P. tenuibrachiatus*, *P. quinquangularis*, *P. radiatus* and *P. salignoideus;* but *Poteriocrinus curtus*, which we referred to it in Pt. I, p. 115, is a *Homocrinus.*

b. *Botryocrinites.*

ATELESTOCRINUS, nov. gen.

'ατελέστος, incomplete ; *κρίνον*, a lily.

Pl. 6, fig. 4, and Pl. 9, fig. 4.

We have had, for several years, a very remarkable Crinoid from the Burlington limestone, which could not be placed in any of the established genera. At first we took it to be an abnormal specimen, with only four radials, and a small non-arm-bearing plate at the anterior side, and therefore did not describe it. It resembles *Belemnocrinus* in its general appearance, but differs in having underbasals, and curiously enough, these have a similar cylindrical form, and are as solid as the basals in that interesting genus.

We have since obtained from the Burlington and Keokuk transition bed near Burlington, and from the lower part of the Keokuk limestone proper of Tennessee, two additional specimens, clearly of the same genus, but of a different species. Both specimens show the same irregular structure, *i. e.*, four arm-bearing radials, and in line with them a small azygous, non-arm-bearing plate, thus proving that the apparent irregularity is a persistent character.

Generic Diagnosis.—Form of calyx elongate, bell-shaped, the sides concave, constricted along the suture between basals and underbasals. Underbasals five, large, forming an almost solid ovo-cylindrical body, pierced only by a longitudinal canal. Basals long and narrow, widening above, irregular in form; three of them hexagonal, two heptagonal. Radials four, of nearly equal size, with an obtuse facet covering the greater part of the width of the plate. Anterior radial non-arm-bearing. Like the regular radials, it alternates with the basals, has the same general height, but less than half their width. Brachials from two to four, exceptionally five; comparatively strong; with parallel articular lines, except the upper one, which is axillary. Main arms eight, which from every second joint, alternately, give off armlets, or arm-like pinnules of less than half the size of the main arms, but extending to the same height and branching. The arm joints, from which the branches are given off, are formed almost like axillary plates, one side, however, being shorter and slightly more obtuse. The alternate joints are quadrangular. Whether these and the axillaries are united by syzygy, could not be ascertained from the specimens.

Azygous plate large, resting between the upper sloping sides of two basals, and against the right posterior radial. It supports towards the left the anal plate, and at its truncate upper side the first plate of the tube. Nothing is known of the ventral side. Column obtusely pentangular, with a medium-sized central canal.

Attelesocrinus delicatus, nov. sp

Calyx bell-shaped; twice as high as wide, greatly constricted along the sutures between basals and underbasals. Underbasals forming a comparatively long ovo-cylindrical body. Basal cup funnel-shaped, resting upon the underbasals as if proceeding from their inner cavity. The basals are delicate plates, elongate, gradually increasing in width. Arm-bearing radials wider than high; each one supporting two brachials. The latter fill nearly the entire width of the preceding plate, and are twice as wide as the true arm plates. Anterior radial narrow, less than half the width of the arm-bearing radials. Arms two to the ray, tapering gradually to their tips, where they become extremely delicate; they have a waving outline, are composed of long joints, and give off armlets alternately from every second plate. All armlets extend to the tips of the arms, and branch once or twice. Their size along the lower part of the arms is only half that of the main arms, but higher up they are of almost equal thickness. Column obtusely pentangular.

Geological Position, etc.—Lower Burlington limestone. Burlington, Iowa.

Atelestocrinus robustus, nov. sp., Pl. 9, fig. 4.

Larger and much more robust than the preceding species; less constricted between basals and underbasals; the form of the latter, taken together, more oblate. Basals twice as long as wide. Arm-bearing radials heavy, wider than high; the anterior radial less than one-third the size of the others, hexagonal. Azygous side with four plates in the calyx, two of them constituting parts of the ventral tube; alternately arranged. Brachials four; three of them quadrangular, the upper one axillary; all rather large, but decreasing in size upwards. Arms long, comparatively heavy at the base, but tapering rapidly to the tips, where they become very delicate. They are composed of quadrangular, rounded joints, with parallel sutures, giving off armlets alternately from every second joint. The armlets are much thinner, and more pinnule-like than in *A. delicatus*, but extend like those to the height of the arms, and bifurcate in a similar manner.

Geological Position, etc.— Burlington and Keokuk Transition bed near Burlington, Iowa, and at the base of the Keokuk limestone, White's Creek Spring, near Nashville, Tennessee.

VASOCRINUS Lyon, Rev. i, p. 97.

STREPTOCRINUS W. and Sp.

στρεπτὸς, twisted ; κρίνον, a lily.

Ophiocrinus Angelin, 1878. Rev. i, p. 97.

The name *Ophiocrinus* is preoccupied by Salter, who proposed it in 1856 for a Rhodocrinoid from Southern Africa, which, however, is not properly defined. Semper also used the name in 1868 for a Neocrinoid, and again Charlesworth, but without publishing the description. The Swedish form, therefore, requires a new name, for which we adopt *Streptocrinus*, in allusion to the convoluted state of the ventral tube.

***Streptocrinus crotalurus** (Angelin), **Ophiocrinus crotalurus**, Iconogr. Crin. Suec., p. 24, Pl. 4, figs. 8 a–c.—Upper Silurian. Gothland, Sweden.

BOTRYOCRINUS Angelin, Rev. I, p. 97.

SICYOCRINUS Angelin, Rev. I, p. 99.

BARYCRINUS Wachsmuth, Rev. I, p. 99.

The genus *Barycrinus* differs from other Cyathocrinidæ in having a shallow calyx, constructed of heavy plates, arms massive, and composed of short joints. These differences are so marked that we have strong doubts whether it ought to be placed in this family.

The diagram of *Barycrinus*, Pl. I, fig. 3, in Part I of this Revision, is incorrect as to the axial canal, which should have shown the processes *radial*, instead of interradial. On page 101, of Part I, we were made to say that the sections of the column of *Barycrinus* are radial and the sutures interradial, whereas it should be that the sections of the column are "*interradial* and the sutures *radial;* the opposite of *Heterocrinus*, in which they are interradial."

No new species have been described since our list, but *Arachnocrinus bulbosus* (Hall), W. and Sp., was referred by S. A. Miller erroneously to *Barycrinus.*

Cyathocrinus subtumidus M. and W., which we took to be a *Barycrinus*, must be changed back to *Cyathocrinus*. The species is closely allied to *Cyathocrinus barydactylus* W. and Sp.

c. *Cyathocrinites.*

CYATHOCRINUS J. S. Miller, Rev. I, p. 79.

Through the kindness of Prof. Whiteaves we had an opportunity to examine E. Billings' type specimens of *Palæocrinus* in the Canada Survey Museum. The specimen of *P. striatus*, upon which the genus was proposed, is very imperfect, and may be a *Carabocrinus*, *Dendrocrinus*, or a new genus. The construction at the ventral side, to which E. Billings attached so much weight, is that of the Cyathocrinidæ generally. They nearly all have ventrally five interradial plates resting against the radials, and alternate rows of covering plates. Heretofore we have placed *Palæocrinus angulatus* Billings under *Cyathocrinus*, but we satisfied ourselves from the original specimen that it is a true *Dendrocrinus.*—*Cyathocrinus fasciatus* Hall, is a synonym of *Macrostylocrinus Meeki; Cyathocrinus hamiltonensis* Worthen, a synonym of *Cyathocrinus parvibrachiatus* Hall. *C. nucleus* and *C. polyxo* Hall are now referred by us to *Homocrinus; C. waldronensis* to *Macrostylocrinus.*—*Cyathocrinus graphicus* Bigsby (not Hall) is *Platycrinus graphicus.*

1879. (?) **Cyathocrinus Harrisi** S. A. Miller, Journ. Cincin. Soc. Nat. Hist., vol. ii, Pl. 15, fig. 2.—Keokuk limest. Crawfordsville, Ind.

We leave this species for the present under *Cyathocrinus*, although aware that it represents a very different generic form. In some respects the species closely resembles *Belemnocrinus florifer*, and might almost be considered identical with it, if the column did not indicate a dicyclic base. The column of both species is sharply pentagonal, and beautifully fringed with whorls of cirrhi, but while in *Belemnocrinus florifer* the outer angles of the column are directed radially, the cirrhi interradially, the very opposite is the case in *Cyathocrinus* (?) *Harrisi.* Neither can the species be referred to our genus *Atelestocrinus*, as this is remarkable for its large underbasals, nor in fact to any other known to us, and we should make it the type of a new genus if the two specimens which we examined were more perfect. The specimen in the collection of Mr. Harris, which he had the kindness to send us for examination, leaves us in doubt whether the so-called azygous plate of Miller does not represent the anterior radial. Among the Fistulata the anterior ray very frequently supports a single arm, which either remains simple or branches on a level with the second bifurcation in the other rays, and this may be the case here. Miller in describing the species, we think, had in mind the Silurian genus *Iocrinus*, in which the plates of the ventral sac take the form of arm plates, but these are given off laterally from the azygous plate and not, as it would be here, from the truncated upper side of the anal piece.

1869. **Cyathocrinus inspiratus** (?) Lyon, Trans. Amer. Philos. Soc., vol. xiii, p. 457, Pl. 27, fig. k.—Keokuk gr. Crawfordsville, Ind. The description is not sufficient for specific identification.

1882. **C. marshallensis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 33, Geol. Rep. Ill., vol. vii, p. 310, Pl. 30, fig. 4.—Kinderhook gr. Marshalltown, Ia. (A connecting link with **Parisocrinus.**)

*1844. **C. Milleri** McCoy (**Atocrinus Milleri**), Synops. Carb. Foss. Ireland, p. 123, Pl. 25; F. Roemer, 1855, Leth. Geogn. (2d Ed.), p. 246, Pl. 4, fig. 12; Bronn's Klassen d. Thierreichs, Pl. 28, fig. 6.—Subcarb. Ireland.

(?)1880. **C.** (?) **stillativus** White, Proceed. Nat. Mus. for 1879, p. 258, Pl. 1, figs. 9, 10; 12th Ann. Rep. Terr. for 1878, by Hayden (Author's Ed., p. 125, Pl. 35, figs. 3 a, b).—Carboniferous. Collected 30 miles west of Humboldt, Kansas. This is no **Cyathocrinus**; it evidently belongs to the Poteriocrinidæ, but the specimen is too imperfect to be referred properly.

*1865. **C. subtumidus** Meek and Worthen, Proceed. Acad. Nat. Sci. Phila., p. 151; **Barycrinus subumidus** Meek and Worthen, 1868, ibid., p. 340; also Geol. Rep. Ill., vol. v, p. 487, Pl. 13, fig. 3; W. and Sp.; **Barycrinus subtumidus**, 1879, Rev. i, p. 87.—Keokuk limest. Green Co., Ill., and White's Creek Springs, Tennessee.

1881. **C. Van Horni** S. A. Miller, Journ. Cincin. Soc. Nat. Hist., vol. iv (October), Pl. 6, fig. 3.—Niagara gr. Chicago, Illinois.

(?) SPHÆROCRINUS Roemer.

In referring *Sphærocrinus* to the genus *Cyathocrinus* (Rev. I, p. 83), we overlooked the fact that Roemer's type has separate dorsal canals piercing the radials. Whether this character is sufficient for generic distinction is a question which has never been brought up for discussion. It is in this regard worthy of notice that this structure occurs exclusively in species from the Silurian and Upper Devonian, never in the Carboniferous, neither in *Cyathocrinus* nor other genera. Whether all species of *Cyathocrinus* from Gothland and Dudley possess this structure, cannot be ascertained from the figures, but if they do, it may form the basis of a separation which seems to us very desirable. If the genus *Sphærocrinus* is accepted, it will probably include not only *Sphærocrinus geometricus* Goldfuss, Roemer's typical species, but many others.

ARACHNOCRINUS M. and W., Rev. I, p. 92.

In our former list we erroneously placed *Poteriocrinus pisiformis* Roemer under *Arachnocrinus.* From specimens which we obtained lately in western Tennessee, and in which the azygous side and also the brachials are preserved, we are convinced that it is a *Lecanocrinus.*

GISSOCRINUS Angelin, Rev. I, p. 89.

ACHRADOCRINUS Schultze.

1879. Zittel, Handb. d. Palæont., i, p. 364.
1866. Schultze, Echin. Eifl. Kalk., p. 101.

Schultze in defining this genus thought it to be closely allied to *Gasterocoma*, and Zittel and de Loriol place it among the Gasterocomidæ. In our opinion, the similarity between *Gasterocoma* and *Achradocrinus* is more superficial than real. *Gasterocoma* has five underbasals, and the column in addition to the axial canal is provided with four peripheral vessels, which are altogether unrepresented in the other form. The two agree only in the position of the anal aperture. The affinities of *Achradocrinus* are much closer with *Sphærocrinus*, from which it differs only, as far as known, in the position of the anal plate.

Generic Diagnosis.—Dorsal cup deeply cup-shaped; symmetry decidedly bilateral. Underbasals five, equal, of medium size, extending beyond the column, and visible in a side view. Basals five, four of them angular above, the posterior one truncate, and supporting an anal plate. Radials all meeting laterally, three of them equal; the two postero-lateral ones deeply excavated for the reception of the anal plate, which they inclose on three sides by meeting above. The radials are slightly notched at their upper margin, and have upon the outer side of the plate a narrow, horseshoe-like articular facet, pierced by a small dorsal canal, which is located at some distance from the notch. At the azygous side there is only an anal plate, which is subquadrangular, its lateral margins arched, its upper face narrower and excavated for the ventral sac, which is cylindrical and placed between this plate and the lateral extensions of adjoining radials. The tube has a ventral position owing to the strongly inflected upper portions of the radials. Arms unknown. Column circular; with a small central canal.

The only known species is:

1866. **Achradocrinus ventrosus** Schultze, Echin. Eifl. Kalk., p. 101, Pl. 12, fig. 6.—Devonian. Eifel, Germany.

CODIACRINUS Schultze.

1866. Schultze, Monogr. Echin. Eifl. Kalk., p. 31.
1879. Zittel, Handb. d. Palæont., i, p. 364.

Codiacrinus is closely allied to *Achradocrinus;* the anal plate, however, is here, we think, fully resorbed by the radials, and the basals consist only of three plates.

Generic Diagnosis.—Of small size; in the form of a poppy-head, reversed bell-shaped, or subovoid. Plates thin. Symmetry strictly pentamerous.

Underbasals three, forming a pentagon; two of them larger and hexagonal, the third smaller and rhomboidal. Basals equal, pentangular. Radials equal; all touching laterally; upper face concave, with a narrow semicircular lateral articular facet for the reception of the brachials, and with a separate dorsal canal. There is no anal plate in the dorsal cup. Nothing is known of the ventral side, nor of the arms.

The only known species is:

1866. **Codiacrinus granulatus** Schultze, Monogr. Echin. Eifl. Kalk., p. 31, Pl. 3, fig. 9.—Devonian. Eifel, Germany.

LECYTHIOCRINUS White.

1880. White, Proceed. Nat. Mus., p. 256.
1880. White, 12th Ann. Rep. Terr. for 1878 by Hayden, p. 122.
1880. Worthen, Bull. i, Illinois St. Mus. Nat. Hist., p. 37.
1880. Worthen, Illinois Geol. Rep., vol. vii, p. 317.

This name must not be confounded with *Lecythocrinus*, Müller, which represents a very different generic form. The adoption of such similar names, even if permitted by the generally accepted rules, should be avoided. The species for which it was proposed agrees in the arrangement of its calyx plates with *Codiacrinus*, except the articular facet of the radials, which is wider, directed upwards (not obliquely as in that genus), and it has distinct ligamentous fossæ, but apparently no central canal.

1882. **Lecythiocrinus Adamsi** Worthen, Bull. I, Ill. St. Mus. Nat. Hist., p. 37; also Geol. Rep. Ill., p. 317, Pl. 30, fig. 8.—Coal measures. Peoria Co., Ill.

1880. **L. olliculæformis** White, Proc. Nat. Mus. for 1879, p. 256, Pl. 1, figs. 4, 5.—12th Ann. Rep. Terr. by Hayden, for 1878, p. 124, Pl. 35, figs. 2 *a*, 6.—Coal measures. Near Humbold, Kansas.

FAMILY XXII.—POTERIOCRINIDÆ.

It has been stated that the distinction between Poteriocrinidæ and Cyathocrinidæ is based principally upon their different mode of articulation. The articulation, however, in the Poteriocrinidæ undergoes certain modifications, and toward the close of the Carboniferous even the calyx begins to show signs of being capable of slight expansion, if not mobility, the plates being frequently provided with a fossa along their margins; while in others the plates are united by syzygy. Those fossæ which extend over the whole surface of the opposed faces not only occur between the radials, but extend in a vertical direction to the basi-radial suture. That they lodged bundles of ligament is almost beyond doubt, and Dr. P. H. Carpenter, whom we consulted on this subject, regards this union as a suture, but "less close, with longer ligaments, and therefore more expansible and movable, than in an ordinary suture." A syzygial union is found among the species which Trautschold referred to the genus *Cromyocrinus*, and seems to extend in some of them even to the suture between basals and underbasals, the striation being plainly visible along the suture lines. In some of these genera the articulation between brachials and arm plates is as highly differentiated as in most of the Neocrinoidea, and much more so than in some of them.

The progressive development in the mode of articulation that takes place from the earlier to the later Poteriocrinidæ is, no doubt, of some classificatory value, but we have not been able, as yet, to separate them on this ground, as the respective parts are generally in an imperfect state of preservation, and there appear to be no other distinguishing characters. Moreover, a comparison of the earlier Poteriocrinidæ, such as *Scytalocrinus*, *Scaphiocrinus*, *Pachylocrinus*, *Cœliocrinus* and *Graphiocrinus*, with the latter genera *Eupachycrinus*, *Zeacrinus*, *Hydreionocrinus*, *Ceriocrinus*, *Erisocrinus*, and of the latter with *Encrinus*, shows that the two sections shade into one another by such easy gradations, that in many cases it is absolutely impossible to draw a dividing line.

The genera of the Poteriocrinidæ are principally based upon the arrangement of the plates at the azygous side, the form of the calyx, the proportionate size of the ventral sac, and the branching of the arms. Some of the genera have a well-developed azygous plate, a special anal piece, and one of the plates supporting the ventral sac enclosed within the calyx. Others, such as *Graphiocrinus* and *Ceriocrinus*, have no azygous plate, but only an anal piece; while in *Erisocrinus*, *Stemmatocrinus* and *Encrinus* no such plate is found, either within the ring of radials or below. In the same degree as palæontologically the calyx grows more symmetrical, the ventral sac decreases in size, and probably disappeared entirely in *Encrinus*, which is closely allied to the Poteriocrinidæ. Along with these modifications, others are going on which take place in the arms. Throughout every genus, a development goes on from the uniserial to the biserial arm structure, a feature which has not been observed in any other family of the Fistulata, and which has no parallel throughout the Neocrinoidea if we exclude *Encrinus*, which we regard as a somewhat higher developed Poteriocrinoid. *Encrinus*, especially, offers in its arm structure a very striking example. Among its species are found arms in all stages of development, some having single quadrangular joints, others two rows closely arranged. The same variations are found in the arms of *Eupachycrinus*, *Ceriocrinus* and *Erisocrinus;* while in the earlier Poteriocrinites the arms never pass beyond the interlocking stage. That the biserial arm structure was developed from single cuneate joints, and not only palæontologically, but also in the growing animal, we had opportunity to observe in a very young *Encrinus liliiformis*, in which the arms, to about two-thirds their height, are composed of single joints, which gradually become more cuneate, and toward the tips are interlocking. This one case, we think, alone would be sufficient evidence to prove that the biserial arm structure is the higher form, if it was not confirmed by other specimens of this and other groups. If *Encrinus* were a Neocrinoid, as supposed by Zittel, De Loriol and Carpenter, the Neocrinoidea would begin their existence with the highest differentiated arms known to us, and the arms of all other Neocrinoidea up to the Comatulæ of the present seas, would appear to have remained persistently in their larval state. This does not seem to us to favor the idea of *Encrinus* being a Neocrinoid.

Comparing *Erisocrinus* with *Encrinus*, the only noticeable difference in their fossil state is the presence of a single brachial in the former, and two in the latter. To this P. H. Carpenter alluded (Chall. Rep., p. 154), admitting it to be "the only point of difference about which we are enabled to speak with certainty." This character, however, is not restricted to *Encrinus*; we find it more or less among all Poteriocrinidæ, but exclusively there and in the Encrinidæ. The two brachials are always joined by suture, not by articulation, and this is the case in *Encrinus*, in which the two pieces are united by syzygy and form actually one plate. The compound brachial is scarcely more than a specific character, and hence has no value as a distinction between two orders.

Carpenter takes not only *Encrinus*, but also *Erisocrinus* and *Stemmatocrinus* to be Neocrinoidea, because they have no anal plate. Anal plates, he states, "are absent in *Erisocrinus* as in *Encrinus*, and since a ventral tube or sac like that of *Cyathocrinus* is always found associated with a system of anal plates, the lowest of which is intercalated between two radials, it seems rash to postulate its presence in the symmetrical *Erisocrinus*." That our conclusions were not so "rash" as Carpenter suggested is emphatically proved by the fact that an anal plate has actually been discovered by Dr. White in *Erisocrinus*. It is located above the radials, being enclosed among the interradial plates, where we should have expected it from analogy with other groups. Anal plates are absent also in two genera of the Cyathocrinidæ, in *Codiacrinus* Schultze, and *Lecythiocrinus* White, which both have a perfectly symmetrical dorsal cup. But does that make them Neocrinoidea? What more do we know of the ventral structure of the Poteriocrinidæ than of *Encrinus* and *Erisocrinus?* If *Encrinus* is a Neocrinoid, why not all Poteriocrinidæ? Nobody ever saw the ventral covering in any Poteriocrinoid—we have only found the ventral sac. Yet from analogy with *Cyathocrinus* and allied forms in which a vault has actually been observed, it was generally supposed that vault plates were present also in the Poteriocrinidæ. We think the width of the brachials, which in this family frequently occupy the entire width of the radials, gives a satisfactory explanation why the vault plates are not preserved in forms like these. The plates either rested against the sloping edges of the radials as in *Stemmatocrinus Trautscholdi*, or only against their articular extensions as in *Symbathocrinus*. It is even very possible that the interradials were partially or wholly resorbed by the muscular processes of the radials, as these became developed in the growing Crinoid.

The subdivisions of *Poteriocrinus*, which we proposed, have been accepted by Wetherby and Williams, but ignored by S. A. Miller and Prof. Worthen.[1]

Extensive collections made by us during the last two years, enable us to give additional information respecting these divisions. *Parisocrinus* proves to be not only a good genus, but, moreover, is a Cyathocrinoid, having no pinnules. *Pachylocrinus* is closer allied to *Zeacrinus* than to *Poteriocrinus*, and is probably identical with *Philocrinus*. De Koninck described this genus with a monocyclic base, and the calyx strictly pentahedral, but from appearance it had underbasals and azygous plates, and is identical with *Pachylocrinus*. We have redefined *Scytalocrinus* and *Decadocrinus*, which should both be ranked as subgenera under *Poteriocrinus*, and likewise *Scaphiocrinus*.

Mr. Percy Sladen, in a paper " On the genus Poteriocrinus and allied forms " (read before the Geol. and Polyt. Soc. at Yorkshire in 1877), separated the English Carboniferous Poteriocrinites into four groups: *Poteriocrinus*, *Dactylocrinus*, *Scaphiocrinus* and *Zeacrinus*. To the typical form he referred: *P. crassus*, *P. spissus*, *P. conicus*. *P. plicatus*, *P. impressus*, *P. radiatus* and *P. quinquangularis*. We agree with him as to the first four species, but we think the last three are Cyathocrinidæ and should be referred to *Parisocrinus*. Mr. Sladen, unfortunately, figured

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[1] S. A. Miller, in the 2d Ed. of his Catal. of Pal. Foss., called them "subgenera of doubtful utility." Prof. Worthen gives the following reasons for refusing their acceptance (Bull. i, Illinois St. Mus. Nat. Hist., p. 4): "First, I see no beneficial result that is likely to come from cumbering the nomenclature of paleontology with such terms, and secondly, because any proposed subgeneric formula that groups together such diverse forms as *Zeacrinus maniformis* Y. and Sh., and *Poteriocrinus Biselli* Worthen, can be of no practical advantage in the study of this group of Crinoids, and hence, until some satisfactory generic characters can be pointed out by which they may be separated, it seems advisable to include them all under the generic name originally proposed by Miller for them." If our good friend had read our paper more carefully, he would have observed that we proposed our six subdivisions of *Poteriocrinus* with the distinct statement that we "scarcely deemed the characters upon which they are based sufficiently important even for subgeneric separation," and that we alluded in detail to the difficulty of referring the "*Zeacrinus*" *maniformis* to any of the sections. In proposing these subdivisions, however, we only followed the suggestion of Meek and Worthen in 1869 (Proc. Acad. Nat. Sci. Phila., p. 138 and note), where, after defining *Scaphiocrinus*, *Zeacrinus* and *Cœliocrinus* as subgenera under *Poteriocrinus*, they add, under the head of *Scaphiocrinus*: "The group, however, has been extended by Prof. Hall and others so as to include species presenting all the characters given above, and might be divided into several sections, distinguished from each other and from the

Parisocrinus radiatus to illustrate the genus *Poteriocrinus*, a species without pinnules, with the arms of a *Cyathocrinus*, but with a *Poteriocrinus* arrangement of azygous plates. Under *Dactylocrinus* he included *P. tenuis*, both of Miller and Austin, *T. isacobus* and *P. rostratus*, Austin (pars), Monogr. Rec. and Foss. Crin. Pl. 9, figs. 2 b, c (non 2 a, d). Comparing Austin's *P. tenuis*, which Sladen redescribed as *Dactylocrinus loreus*, with "*Poteriocrinus*" *radiatus*, there appears to be considerable difference between the two forms, but comparing it with *P. crassus*, Miller's typical species, the difference is not so very great. Austin's figure apparently was made from a very young specimen, as indicated by the unusually long arm joints, and it may be a somewhat aberrant form of *Scytalocrinus*. Sladen's name *Dactylocrinus* would have priority over *Scytalocrinus*, had not Quenstedt in 1876 used the same name for a different form. *P. isacobus* is, in our opinion, a good *Poteriocrinus*. Sladen refers to *Scaphiocrinus: P. latifrons*, Austin, which we take to be a *Pachylocrinus;* and to *Zeacrinus: Cupressocrinus impressus* (*Cupressocrinus calyx*, McCoy); *Poteriocrinus McCoyanus*, and *Zeacrinus Phillipsi*. We agree with him as to the latter species, but we doubt if the other three are sufficiently known to assert whether the calices belong to either *Zeacrinus*, *Eupachycrinus* or *Hydreionocrinus*.

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typical form, on quite as good characters as those distinguishing the latter from *Zeacrinus*." At the time of J. S. Miller the genus *Poteriocrinus* was fully sufficient to hold every species then known, but for each species then known one hundred have been discovered since.

When we attempted to revise the Poteriocrinites we found a confusion such as existed in no other group of the Palæocrinoidea. The subdivisions that had been proposed were so indistinctly defined, and contained such diverse elements, that they rather increased the difficulty instead of diminishing it. As a temporary remedy we proposed our subdivisions, and expecting they would eventually prove to be distinct genera, we applied to them at once generic names. It was at the option of Prof. Worthen to accept these divisions or not, but in adding some fifty or more species to the three hundred already described, he surely would have aided in the identification of his species, and science generally, by referring them to those groups. This would have lightened the labors of others, who are now compelled to look up for comparison every one of his species. Besides, if Prof. Worthen had consulted the Revision, he might have avoided a number of synonyms, which "cumber the nomenclature of paleontology" more seriously than those few systematic names. It is somewhat curious that after refusing to accept the subgenera proposed by us and Prof. Hall, Prof. Worthen repeatedly employs the specific names which had already been used by previous writers in one or the other of those subgenera.

a. *Poteriocrinites.*

POTERIOCRINUS J. S. Miller.

Rev. I, p. 111.

Dorsal cup obconical; plates delicate and frequently covered with wrinkles or radiating plications. Radials with a semicircular scar, facing outward, and provided with a transverse articular ridge. Brachials one; laterally constricted; sutures gaping. Arms long and branching; composed of wedge-formed plates. Ventral sac long, constructed of six longitudinal rows of short transverse plates forming a tube; one of these rows resting upon the anal piece, another upon the third azygous plate. The plates of the tube, which are heavier along their median line, are provided laterally with transverse ridges or plications, which all have long open slits along their margins. Column circular.

We add the following species to our list:

1882. **Poteriocrinus Clarkii** Williams, Proc. Acad. Nat. Sci. Phila., p. 21, Pl. 1, fig. 4.—Chemung gr. Steuben Co., N. Y.

Var. alpha, ibid., p. 22, Pl. 1, fig. 5.—Chemung gr. Ithaca, N. Y.

1882. **P. cornellianus** Williams, Proc. Acad. Nat. Sci. Phila., p. 18, Pl. 1, figs, 1, 2, 3.—Chemung gr. Ithaca, N. Y.

1836. **P. impressus** Phill. (not McCoy, 1854 = **Hydreionocrinus McCoyanus,** nor Richter and Unger, 1860). Geol. Yorkshire, p. 205, Pl. 4, fig. 1.—Austin, 1843, Rec. and Foss. Crin., p. 10, fig. 6.—W. and Sp., Rev. i, p. 120.—Sladen, 1877, On the Genus Poteriocrinus, p. 8.—Bristol, England.

1882. **P. otterensis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 14: also Geol. Rep. Illinois vii, p. 283, Pl. 28, fig. 4.—Otter Creek, Jersey Co., Ill.

Species having the characters of the Poteriocrinites, but not sufficiently known to be referred to the proper genus:

P. æmulus Hall, 1879, Eleventh Indiana Rep., p. 266, is probably a **Homocrinus** (?).

1880. **P. anomalos** Wetherby, Journ. Cincin. Soc. Nat. Hist. (July), p. 15, Pl. 5, fig. 6.—Kaskaskia gr. Pulaski Co., Ky.—This is one of the most perplexing species of this group. It agrees neither with **Graphiocrinus,** nor **Decadocrinus,** nor **Scaphiocrinus,** nor **Eupachycrinus,** and really shades into all of them.

1882. **P. arachnæformis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 13, Pl. 28, fig. 12: also Geol. Rep. Illinois, vii, p. 281, Pl. 28, fig. 12.—Keokuk limest. Warsaw, Ill.

P. Bockschii Geinitz. Only known to us from quotations.

P. calyx Hall, 1879 (non De Koninck, 1853), is only defined from basal plates.—Niagara gr.

1882. **P. clytis** Worthen, Bull. No. 1, Ill. St. Mus. Nat. Hist., P. 16 (not **P. clytis** on p. 25); also Geol. Rep. Ill., vii, p. 294, Pl. 30, fig. 10.—St. Louis limest. Monroe Co., Ill.—A very young specimen, as seen by the form of the brachials and arm joints; it probably had 10 arms in its adult state.

1849. **P. crassimanus** McCoy (not **P. crassimanus** Eichw.), Ann. and Mag. Nat. Hist. (Ser. ii), vol. iii, p. 245.—Contrib. Palæont., p. 106.—Carboniferous, Derbyshire.

1882. **P. illinoisiensis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 10; also Geol. Rep. Illinois, vii, p. 289, Pl. 28, fig. 17—Warsaw limest. Warsaw, Ill.

1844. **P. inequidactylus** McCoy, Carboniferous Foss. Ireland, p. 179, Pl. 26, fig. 8.—Carboniferous. Ireland.

P. minimus Austin (not Ad. Roemer) is probably a synonym of **Scaphiocrinus isacobus.**

1882. **P. similis** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 23; also Geol. Rep. Illinois, vii, p. 295, Pl. 30, fig. 12.—Kaskaskia limest. Monroe Co., Ill. This is evidently a young specimen, probably of one of the other species.

1882. **P. validus** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 18; also Geol. Rep. Illinois, vii, p. 287, Pl. 28, fig. 16.—Warsaw limest. Warsaw, Ill.

SCAPHIOCRINUS Hall, Rev. I, p. 112.

(Emend. W. and Sp.)

Dorsal cup obconical to semi-ovoid; all its plates closely united by suture. Radials truncate above, the articular ridge filling almost the entire width of the upper face. Brachials long, simple or compound, similar in form to the radials but truncate below; line of articulation gaping. In species with compound brachials, the two segments have the form and proportions of the one plate in the others, and are joined by suture. Arms long, branching; arm joints rather long, wedge-form. Azygous side as in *Poteriocrinus.* Column obtusely pentagular.

Poteriocrinus Jesupi Whitfield, Amer. Mus. Nat. Hist. N. Y., Bull. i (Decbr., 1881), is evidently a synonym of *P. Swallovi* M. and W. (compare Ill. Rep., ii, Pl. 16, fig. 4), although Whitfield thinks it distinct in the bifurcation of the arms, and in the number and arrangement of the anal plates. In the type specimen of *P. Swallovi* only two bifurcations of the arms were preserved, and Meek and Worthen remarked on p. 84, that the arms in the upper parts " seemed to be simple " in this species. The latter is not confirmed by our specimens, of which many have arms and ventral sac beautifully preserved; they all show essentially the same bifurcations as Whitfield's specimen. Slight variation in the number of arm joints in one of the bifurcations cannot be regarded as a good specific character, and even an additional division of the arms may take place in the same species. The apparent variation in the number of " anal " plates is explained by the fact that in the type of *P. Swallovi* the arms accidentally cover the lower portion of the ventral sac, exposing to view only four plates; while in Whitfield's specimen a much greater portion of the ventral sac is visible.

The following species are to be added to our former list :

a. *With simple brachials.*

*1882. **Scaphiocrinus kaskaskiensis** (Worthen), **Poteriocrinus kaskaskiensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 27; also Geol. Rep. Ill., vii, p. 300, Pl. 30, fig. 15.—Kaskaskia limest. Near Chester, Ill.

*1882. **S. latidactylus** (Worthen), **Poteriocrinus latidactylus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 8; also Geol. Rep. Ill., vii, p. 275, Pl. 28, fig. 6.—Keokuk limest. Hamilton, Ill.

*1884. **S. obscurus** W. and Sp. (**Poteriocrinus tenuidactylus** Worthen), Bull. i, of the Ill. St. Mus. Nat. Hist., p. 6 (not p. 10; nor **Pot. [Scaph.] tenuidactylus** M. and W., 1865); also Geol. Rep. Illinois, vii, p. 271, Pl. 28, fig. 13.—Keokuk limest. Keokuk, Iowa. The specific name being preoccupied by M. and W. in Geol. Rep. Ill., iii, p. 490, Pl. 18, fig. 10, we propose for this species the above name.

*1882. **S. occidentalis** (Worthen), **Poteriocrinus occidentalis** Worthen (not Shum.), Bull. i, Ill. St. Mus. Nat. Hist., p. 10; also Geol. Rep. Illinois, vii, p. 278, Pl. 29, fig. 2.—Keokuk limest. Hamilton, Ill. The name **Pot. occidentalis** was preoccupied, in 1852, by Owen and Shum., Geol. Rep. of Wisc., Iowa and Minnesota, p. 596, Pl. 5 b, fig. 5; but, as it has since been referred to **Agassizocrinus,** we propose retaining Worthen's name for the above species.

*1882. **S. okawensis** (Worthen), **Poteriocrinus okawensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 24; also Geol. Rep. Illinois, vii, p. 296, Pl. 29, fig. 2.—Kaskaskia gr. Okaw River, Ill.

*1882. **S. Orestes** (Worthen), **Poteriocrinus Orestes,** Bull. i, Ill. St. Mus. Nat. Hist., p. 7; also Geol. Rep. Illinois, vii, p. 273, Pl. 27, fig. 3.—Keokuk limest. Keokuk, Iowa. (Compare with **Scaph. Coreyi** M. & W.)

*1882. **S. popensis** (Worthen), **Poteriocrinus popensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 23; also Geol. Rep. Illinois, p. 296, Pl. 29, fig. 12.—Kaskaskia gr. Pope Co., Ill.

*1882. **S. propinquus** (Worthen), **Poteriocrinus propinquus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 26; Geol. Rep. Ill., vii, Pl. 29, fig. 9.—Kaskaskia gr. Monroe Co., Ill.

*1882. **S. Salteri** (Worthen), **Poteriocrinus Salteri,** Bull. i, Ill. St. Mus. Nat. Hist., p. 21; Geol. Rep. Ill., vii, Pl. 29, fig. 18.—Kaskaskia gr. Chester, Ill.

1880. **S spinifer** Wetherby, Journ. Cincin. Soc. Nat. Hist. (July), p. 13, Pl. 5, fig. 5.—**Graphiocrinus spinifer** S. A. Miller, 1883, Catalogue Amer. Pal. Foss. Ed. ii, p. 287.—Kaskaskia gr. Pulaski Co., Ky.

*1882. **S. spinobrachiatus** (Worthen), **Poteriocrinus spinobrachiatus** (not Hall), Bull. i, Ill. St. Mus. Nat. Hist., p. 20; also Geol. Rep. Ill., vii, p. 290, Pl. 29, fig. 1.—Kaskaskia gr. Monroe Co., Ill. Hall described in 1861 a species under **P. (Scaphiocrinus) spinobrachiatus,** which we referred in Rev. i, p. 123, to **Graphiocrinus.**

*1882. **S. varsoviensis** (Worthen), **Poteriocrinus varsoviensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 20; also Geol. Rep. Illinois, vii. p. 290, Pl. 28, fig. 15.—Warsaw limest. Warsaw, Ill.

*1882. **S. venustus** (Worthen), **Poteriocrinus venustus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 24; also Geol. Rep. Ill., vii, p. 297, Pl. 29, fig. 13.—Kaskaskia gr. Monroe Co., Ill.

Syn. **P. peculiaris** Worthen, (described Bull. i, Ill. St. Mus. Nat. Hist., p. 25, as **Pot. clytis**), Geol. Rep. Ill., vii, p. 298, Pl. 29, fig. 10.—The specimen from which the species was described has an anomalous arrangement of anal plates.

b. *With compound brachials.*

*1882. **S. briareus** (Worthen), **Poteriocrinus briareus**, Bull. i, Ill. St. Mus. Nat. Hist., p. 12; also Geol. Rep. Ill., vii, p. 279, Pl. 27, fig. 4.—Keokuk limest. Keokuk, Ia., and Bono, Ind. The specific name is given at all places as **P. briærius**, but evidently was intended for **Pot. briareus.**

*1882. **S. Burketi** (Worthen), **Poteriocrinus Burketi**, Bull. i, Ill. St. Mus. Nat. Hist., p. 5; also Geol. Rep. Illinois, vii, p. 270, Pl. 28, fig. 8.—Keokuk limest. Hamilton, Ill.

*1882. **S. coxanus** (Worthen), **Poteriocrinus coxanus**, Bull. i, Ill. St. Mus. Nat. Hist., p. 4; also Geol. Rep. Illinois, vii, p. 269, Pl. 27, fig. 1.—Keokuk limest. Keokuk, Iowa.

S. cultidactylus Hall, 1859, was redescribed and figured Geol. Rep. Illinois, vii, p. 301, Pl. 30, fig. 1.

*1884. **S. extensus** W. & Sp., **Poteriocrinus asper** Worthen, not **Pot.** (**Pachylocr.**) **asper** (W. & Sp., Rev. i, p. 116), Bull. i, Ill. St. Mus. Nat. Hist., p. 11; also Geol. Rep. Illinois, vii, p. 278, Pl. 27, fig. 8.—Keokuk limest. Keokuk, Iowa.

Poteriocrinus asper being preoccupied, we propose the above name in place of it.

*1882. **S. iowensis** (Worthen), **Poteriocrinus iowensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 6; also Geol. Rep. Illinois, vii, p. 272.—Keokuk limest. Hamilton, Ill.

*1844. **S. macrocheirus** (McCoy), **Cyathocrinus macrocheirus**, Synop. Carb. Foss. Ireland, Pl. 25, figs. 8, 10.—Subcarboniferous, Ireland. (This species has three brachials.)

*1873. **S. montanaensis** (Meek), **Poteriocrinus montanaensis**, Ann. Rep. U. S. Geol. Rep. Terr. for 1872, p. 469; also White, 12th Ann. Rep. of the Terr., by Hayden, for 1878, p. 128, Pl. 33, fig. 6 a.—Carboniferous. Virginia City Montana.

*1882. **S. nauvooensis** (Worthen), **Poteriocrinus nauvooensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 13; also Geol. Rep. Illinois, vii, p. 282, Pl. 28, fig. 10.—Keokuk limest. Nauvoo, Ill.

*1882. **S. pikensis** (Worthen), **Zeacrinus pikensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 304; Geol. Rep. Ill., vii, Pl. 30, fig. 3.—Burlington limest. Pike Co., Illinois.

*1882. **S. sculptus** (Worthen), **Poteriocrinus sculptus**, Bull. i, Ill. St. Mus. Nat. Hist., p. 21; also Geol. Rep. Illinois, vii, p. 292, Pl. 29, fig. 8.—Kaskaskia gr. Monroe Co., Ill.

(**Poteriocrinus subramulosus** Worthen, Ill. St. Mus. Nat. Hist., p. 14; Geol. Rep. Illinois, vii, p. 284, is a synonym of **Pot.** (**Scaphiocrinus**) **Swallovi** M. & W. This species passes from the upper part of the Upper Burlington into the Keokuk limestone).

SCYTALOCRINUS W. and Sp., Rev. I, p. 116.

Syn. *Dactilocrinus* Sladen, 1877 (not Quenstedt), in part (On the genus Poteriocrinus, p. 4).

General form, including arms, slender, almost cylindrical. Dorsal cup obconical or bell-shaped; plates strong but not massive, connected by close suture. Underbasals well developed, bent upward and forming a conspicuous part of the calyx. Radials and brachials of nearly the same form, apposed faces truncate, with a transverse articular ridge and somewhat shallow fossæ; line of articulation gaping. The brachials either single or compound, generally elongate, constricted along the middle. They support two simple arms each, except in the anterior ray, which sometimes has but a single arm. Arms long, rather heavy, composed of quadrangular or slightly cuneiform joints; pinnules of moderate size. Azygous side as in *Poteriocrinus;* ventral sac tubular, with slit-like openings, and frequently spiniferous at the distal end. Column circular or obtusely pentagonal.

Additional species:—

a. *With single brachials.*

*1877. **Scytalocrinus loreus** (Sladen), **Dactylocrinus loreus** (**Poteriocrinus tenuis** Austin, non Miller), Mon. Rec. and Foss. Crin., Pl. 10, fig. 5.—On the genus Poteriocrinus, etc., p. 5.—Subcarboniferous. England.

*1821. **S. tenuis** Miller, Nat. Hist. Crin., p. 71, Pl. 21-23. **Dactylocrinus tenuis** Sladen, 1877, "On the genus Poteriocrinus, p. 5."

*1880. **S. Wachsmuthi** Wetherby, Journ. Cincin. Soc. Nat. Hist. (July), p. 12, Pl. 5, fig. 4.—Kaskaskia limest. Pulaski Co., Ky.

b. *With compound brachials.*

(**Poteriocrinus hamiltonensis** Worthen, 1882, Bull. i, Ill. St. Mus. Nat. Hist., p. 7; Geol. Rep. Illinois, vii, p. 273, Pl. 28, fig. 9, Syn. of **Poteriocr.** (**Scytalocr.**) **robustus** Hall).

*1882. **Scytalocrinus Talboti** (Worthen), **Poteriocrinus Talboti,** Bull. i, Ill. St. Mus. Nat. Hist., p. 17; also Geol. Rep. Illinois, vii, p. 287, Pl. 30, fig. 7.—St. Louis limest. Monroe Co., Ill.

DECADOCRINUS W. and Sp., Rev. I, p. 119.

Arms ten, rarely nine, the anterior ray sometimes undivided. Dorsal cup depressed, saucer-shaped, with a deep concavity along the basal regions. Underbasals small, not seen in a side view, and frequently covered almost entirely by the column. Form of radials and brachials and articulation as in *Scytalocrinus;* brachials simple or compound. Arms composed of single wedge-form joints, with keel-like projections at alternate sides, and with strongly waving or zigzag outlines. Pinnules unusually strong, placed far apart, and resembling armlets; composed of short cuneate joints, with spurs or keels upon their basal joints. Azygous side as in *Poteriocrinus.* Ventral sac more or less club-shaped; constructed of numerous rows of regularly arranged hexagonal pieces, with a pore at each angle. Column pentagonal, with rounded angles.

Decadocrinus agrees closely with *Graphiocrinus*, but the latter has no azygous plate, only an anal piece.

Additional species:—

a. *With simple brachials.*

*1882. **Decadocrinus columbiensis** (Worthen), **Poteriocrinus columbiensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 22; also Geol. Rep. Illinois, vii, p. 293, Pl. 19, fig. 6.—Kaskaskia limest. Monroe Co., Ill.

*1882. **D. fountainensis** (Worthen), **Poteriocrinus fountainensis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 17; also Geol. Rep. Illinois, vii, p. 286, Pl. 30, Fig. 11.—St. Louis limest. Monroe Co., Ill.

*1881. **D. Milleri** (Wetherby), **Poteriocrinus Milleri** (not Worthen), Journ. Cincin. Soc. Nat. Hist. (January), Pl. 9, figs. 12, 13.—Kaskaskia gr. Pulaski Co., Ky.

*1882. **D. penicilliformis** (Worthen), **Poteriocrinus penicilliformis**, Bull. i, Ill. St. Mus. Nat. Hist., p. 8; also Geol. Rep. Illinois, vii, p. 276, Pl. 28, fig. 9.—Keokuk limest. Hamilton, Ill.

1882. **D. zethus** Williams. Proc. Acad. Nat. Sci. Phila., p. 27, Pl. 1, fig. 9.—Portage gr. Ithaca, N. Y.

b. *With compound brachials.*

1882. **D. gregarius** Williams. Proc. Acad. Nat. Sci. Phila., p. 22, Pl. 1, figs. 6, 7, 8.—Chemung gr. Ithaca, N. Y.

WOODOCRINUS De Koninck. Rev. i, p. 124.

(Emended W. and Sp.)

Syn. *Parisocrinus* W. and Sp. Rev. i, p. 115.
Syn. *Zeacrinus* Hall (not Troost) in part. Geol. Rep. Ia., vol. i, p. 544.
Syn. *Zeacrinus* Sladen, 1877. On the genus Poteriocrinus, etc., p. 7.
Syn. (?) *Philocrinus* De Koninck, 1862. Quart. Journ. Geol. Soc. London.

The ventral side of *Woodocrinus* has not been observed, but we may suppose from the spreading of the arms that its sac was rather bulky. This is further suggested by the great width of the azygous side, which, however, is composed of the same elements as in most Poteriocrinites, and is not structurally distinct as has been generally supposed. It has, like *Poteriocrinus*, within the calyx three azygous plates—the succeeding pieces forming the abactinal parts of the ventral sac—which for some distance, are exposed between the arms. It differs from *Scaphiocrinus* in the shortness of its arm joints and arms generally. This it shares, however, with *Pachylocrinus* as defined by us, and with *Zeacrinus* Troost.

In our description of *Zeacrinus* (Rev. i, p. 125), we stated the difficulty of separating it from *Woodocrinus.* The only difference, there noted, was the folding up and the smaller size of the arms in the former, and upon this distinction almost exclusively we based the separation. We also stated that the calyx in *Woodocrinus* was generally more turbinate, in *Zeacrinus* depressed with concave basal regions, but also to this rule we found exceptions among the species which had been referred to the latter. Equally impracticable would be a separation upon the arm joints, although these vary considerably among the typical species. The arms of *Zeacrinus magnoliaformis* are dorsally perfectly flat, those of *Woodocrinus macrodactylus* decidedly rounded, and Hall, Meek, Worthen and White placed under *Zeacrinus* species with flat, rounded and angular arms.

The species which we arranged in Pt. i, under *Pachylocrinus*, had been originally, with a few exceptions, described under *Zeacrinus.* Their arms, like those of the latter, are more or less closely folded up, and they dichotomize in a similar manner. All are composed of short quadrangular joints, and all have a club- or elongate balloon-shaped, ventral sac; while the sac in *Zeacrinus magnoliaformis* is pyramidal, with sharp lateral edges and concave sides. In the latter the form of the calyx is disk-like, in the others bowl-shaped. Mr. Percy Sladen, the only English writer who advocated the necessity of subdividing the original genus *Poteriocrinus*, placed *Poteriocrinus McCoyanus*, *P. calyx*, *P. granulosus* and *P. Phillipsii* under *Zeacrinus.* We fully agree with him that these four species cannot be retained under *Poteriocrinus*, having close affinities with *Zeacrinus*, but we believe the three former will prove to be *Hydreionocrinus*, his *Zeacrinus Phillipsii* a *Pachylocrinus* or *Woodocrinus*, as also *Poteriocrinus latifrons* Austin, which he referred to *Scaphiocrinus.* Sladen probably was not acquainted with Troost's type of *Zeacrinus*, as he took *Z. elegans* to be a typical form, an opinion in which we have shared until quite recently, when we obtained numerous beautifully-preserved specimens, both of "*Zeacrinus*" *elegans* and Troost's typical species, from the Kaskaskia limestone. The later forms differ from the earlier not only in the form of their ventral sac, but also essentially in the construction of their calyx. In the typical species the dorsal cup is disk-like, almost flat, the radials extremely large, touching with their acute lower angles the underbasals, thereby almost isolating the five basals. The basals in these species consist of minute trigonal pieces of irregular form, and also the underbasals are small, and rest deeply within the columnar concavity (Pl. 6, fig. 9). In the earlier form, notably "*Zeacrinus*" *elegans*, however, the basal cup is bowl-shaped, and the basals are comparatively larger. The arrangement of the azygous pieces upon which DeKoninck placed so much stress in defining *Woodocrinus*, is, in our opinion, not different from that of *Poteriocrinus* or *Scaphiocrinus*, only more plates of the ventral sac are exposed to view, owing to the width of the azygous side, and as we see no other distinction between *Woodocrinus* and our *Pachylocrinus*, we place the species which we had referred to the latter, including "*Zeacrinus*" *elegans* and a few others of the same type, under *Woodocrinus*, as this name has priority. Perhaps, if all American species were as distinct as "*Zeacrinus*" *elegans* from *Woodocrinus macrodactylus*, it might be possible to make the former the type of a separate group, but as we find all intermediate forms, from infolding arms to spreading arms, and two to five or more bifurcations, flat, angular and rounded arms, any such separation must be adandoned.

Philocrinus, De Koninck, from Punjaub, India, is probably, to judge from the figure, a species of *Woodocrinus*. We think it has azygous plates, but these were covered by matrix in DeKoninck's specimen. We also doubt if the arm plates of first and second order were laterally connected by suture; these evidently were free as in the Fistulata generally.

Revised Diagnosis.—Calyx sometimes obconical, more frequently depressed-bowl-shaped, and the underbasals bent inward, forming a concavity. Basals large, constituting a continuous ring beneath the radials. Azygous plates arranged as in *Poteriocrinus;* ventral sac slightly inflated. Brachials composed of one or two pieces, which jointly have the form and size of the radials; they are wider than long, and their lateral margins are fitted closely together as if they were united by suture. This infolding of the brachials extends also to the arm plates up to the second bifurcation; and is often found throughout the full length of the arms. The arm joints are short, quadrangular, rarely cuneate, the apposed faces, more or less parallel and flat, angular or rounded on their outer face. The arms dichotomize and each branch gives off one or more branches to the inner side of the ray, which either bifurcate again or remain simple. The articulation is the same as in *Scaphiocrinus.* Column circular, or obtusely pentangular.

The zoological position of *Woodocrinus* is probably between *Scaphiocrinus* and *Zeacrinus.*

Geological Position, etc.—The genus occurs only in the Subcarboniferous, and almost exclusively in the lower portions.

We place under *Woodocrinus* the following species, all of which were referred by us, Rev. i, p. 116, to *Pachylocrinus: Zeacrinus arboreus* Worthen, *Zeacrinus asper* M. and W., *Zeacrinus concinnus* M. and W., *Poteriocrinus latifrons* Austin, *Scaphiocrinus liliiformis* M. and W., *Zeacrinus merope* Hall, *Zeacrinus paternus* Hall, *Zeacrinus perangulatus* White, *Zeacrinus planobrachiatus* M. and W., *Pachylocrinus subæqualis* W. and Sp., and the following, which in Rev. i, p. 128, were placed under *Zeacrinus: Poteriocrinus bursæformis* White, *Zeacrinus elegans* Hall, *Zeacrinus ramosus* Hall, *Zeacrinus scobina* M. and W., *Zeacrinus serratus* M. and W., and *Zeacrinus troostanus* M. and W.

The following species are to be added :—

*1882. **Woodocrinus asperatus** (Worthen), **Poteriocrinus asperatus,** Bull. i, Ill. St. Mus. Nat. Hist., p. 12, also Geol. Rep. Illinois, vii, p. 280, Pl. 28, fig, 2.—Keokuk limest. Keokuk, Ia.

*1882. **W. claytonensis** (Worthen), **Poteriocrinus claytonensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 18; also Geol. Rep. Illinois, vii, p. 288, Pl. 30, fig. 6.—Warsaw limest. Adams Co., Ill.

*1862. (?) **W. cometa** (De Koninck), **Philocrinus cometa,** Quart. Journ. Geol. Soc. London, Pl. ii, fig. 1.—Subcarboniferous. River Indus, India.

1854. **W. macrodactylus** De Koninck. Type of the genus, Recherch. Crin. Belg., Suppl., p. 6, Pl. 8, figs. 1 a-d.—Subcarboniferous. Richmond, England.

*1882. **W. richfieldensis** (Worthen), **Poteriocrinus richfieldensis,** Bull. i, Ill. St. Mus. Nat. Hist., p. 15; also Geol. Rep. Ill., vii, p. 285, Pl. 30, fig. 5.—Waverly (Kinderhook) group. Richfield, O.

*1883. **W. tentaculatus** (Worthen), **Poteriocrinus tenuidactylus,** Bull., i, Ill. St. Mus. Nat. Hist., p. 10; **Poteriocrinus tentaculatus,** Geol. Rep. Ilinois, vii, p. 277, Pl. 28, fig. 11.—Keokuk limest. Keokuk, Ia.—Prof. Worthen finding the former specific name occupied, changed it to the latter. This species is a typical form of Woodocrinus, and has the heavy rounded arms as De Koninck's species.

ZEACRINUS (Troost MS.) Hall, Rev., i, p. 125.

Revised W. and Sp. (Pl. 6, fig. 9, and Pl. 9, fig. 3).

Zeacrinus differs from *Woodocrinus* (*Pachylocrinus*) in the form of the ventral sac, which, as described by us, is pyramidal, sharply angular and pointed at the upper end; while that of *Woodocrinus* is club-shaped, inflated above. The two genera differ also in the construction and form of the dorsal cup, which in *Zeacrinus* is much more depressed and disk-like. Basals exceedingly small, trigonal, deeply notched for the reception of the radials. The underbasals at the inner floor of the calyx are generally larger than they appear at the outer side, and the angles of the radials sometimes touch the underbasals. Plates of the calyx massive, especially the radials, their distal faces sloping outward; articular facets with muscular extensions. Arm plates generally flat, except the axillaries, which frequently are tuberculous. The arms dichotomize toward the inner side of the ray from each main division, the branches rarely dividing again. The arm joints are short, transversely arranged, those of the same rank slightly increasing in width upwards, those of the next order narrower by one-half than the preceding bifurcating plate. By this structure, the arms of each ray, and of the main divisions of the rays, form laterally a straight line, by means of which they fit in so closely against the arms of adjoining rays, that they often appear as if united by suture. Column round, comparatively small.

We now recognize under *Zeacrinus* only the following species, viz.: *Zeacrinus bifurcatus*, *Z. compactilis* Worthen; *Z. magnoliaformis* O. and N.; *Z. ovalis* Lyon and Cass.; *Z. Wortheni* Hall, and our new species *Z. nodosus*, all other species which were referred by us to this genus are found now under *Woodocrinus*.

Zeacrinus nodosus, nov. sp. (Pl. 6, fig. 3).

The largest known species of the genus. All plates of calyx and arms nodose, except basals and underbasals; the nodes on all axillaries, and the first plate of each succeeding order of arm plates, almost covering the entire surface of the plate; while at the intermediate plates the nodes have more the shape of small tubercles, arranged so as to occupy an excentric position, leaning slightly toward the wider or pinnule-bearing side, thereby forming along the arms two rows of nodes, alternately arranged.

Underbasals of medium size, extending beyond the column, forming a shallow inverted cup, decagonal at the outer side. Basals trigonal, very minute, irregular in size, the two anterior ones smaller than the others. Radials large; broadly truncate below; subquadrangular in outline but hexagonal; the three lower faces scarcely as wide as the lateral ones, and narrower by one-half than the upper side. Brachials 1 × 5 ; four of them triangular, giving off two arms each ; the anterior one quadrangular, with only one primary arm. The arms bifurcate on the fifth plate, and again on the tenth to fifteenth; the higher divisions are not known. In this species, exceptionally, the inner arms branch again.

Azygous plate elongate, resting upon the underbasals; the right lateral face, which is slightly convex, abutting against the right posterior radial, its upper side supporting the anal plate; leaning with its left lateral side against the other radial, and with its lower sloping side against the adjoining basal.

Geological Position, etc.—Keokuk limestone. White's Creek Springs, near Nashville, Tenn.

CŒLIOCRINUS White, Rev. I, p. 131.

Syn. *Sphæronites* Phill., Palæoz. Foss. Cornwall, p. 135.

We have heretofore made *Cœliocrinus* a subgenus of *Hydreionocrinus*, owing to slight variations in the form and construction of the ventral sac, which we thought to be the only distinctive character. Beautiful specimens, however, which we obtained since in Kentucky, show that the two forms differ in their mode of articulation in a similar manner as *Woodocrinus* and *Zeacrinus*, *Scytalocrinus* and *Eupachycrinus*, which we ranked as full genera. In *Cœliocrinus* the calyx is conical, in *Hydreionocrinus* depressed —saucer-shaped.

Cœliocrinus is found also in Europe. Phillips, in his work on the Palæoz. Foss. of Cornwall, gives on Pl. 59 a good figure of what we take to be the balloon-shaped ventral sac of this genus. His figure was copied from the Geol. Trans. (new ser.), vol. iii, Pl. 20, which had been published with a note by Mr. Broderip, "calling attention to some analogy between this fossil and *Chelyosoma macleayanum*, a species of tunicate Mollusca, which has a few coriaceous plates on the upper surface only." Phillips, and apparently Austin, took it to be allied to *Echinospherites* of Wahlenberg, and called it provisionally *Sphæronites tessellatus*, which we propose to change into *Cœliocrinus tessellatus*.

In its arm structure *Cœliocrinus* leans decidedly toward *Woodocrinus*, but approaches *Hydreionocrinus* in the form of its sac-like appendage.

We have already referred to it *Cœliocrinus dilatatus* (Hall) White; *C. cariniferus* (Worthen) W. and Sp.; *C. lyra* (Worthen) W. and Sp.; *C. subspinosus* White, and *C. ventricosus* (Hall) White, and now add further:

*1840. **C. tessellatus** (Phill.), **Spæronites tessellatus**, Palæoz. Foss. Cornwall, p. 135, Pl. 59.—Subcarbon. (?). Locality (?).

HYDREIONOCRINUS De Kon., Rev. I, p. 123.

Wetherby, in a paper on the Crinoids of Pulaski Co., Kentucky, figured and described a new species of *Hydreionocrinus*, which he referred with doubt to *Hydreionocrinus* (*Zeacrinus*) *armiger* (M. and W.). Several fine specimens of this form, which we obtained lately at Sloan's Valley, Ky., show it to be specifically distinct from either *H. armiger* or *H. depressus* of the same locality. We propose for it the name *Hydreionocrinus Wetherbyi*, in honor of the discoverer of this interesting locality. The species, which was figured Journ. Cincin. Soc. Nat. Hist., vol. iii, figs. 7, 8, 9, 10, differs from *H. depressus*, with which it has probably the closest affinities, in the less depressed form of the dorsal cup, and in the basal concavity, which is shallow and almost restricted to the underbasals; while in the other the cup is deeply excavated, and the concavity includes even a portion of the radials. In our species, every brachial bifurcates, in the other only four; the anterior radial which is quadrangular, supporting a single primary arm. In the former all five radials are spiniferous, in the latter only four, and the spines are shorter and sharper. In *H. depressus* the primary arms branch four times, in *H. Wetherbyi* only twice, and the arms, which in the former taper to a small point, remain comparatively heavy in the latter. Again, in *H. depressus* the arm joints, from the second bifurcation upwards, are biserial, while in *H. Wetherbyi* they do not pass the interlocking stage. In the former the ventral sac is armed with ten spines which join along the centre, the latter has five only, and these enclose a variable number of small plates.

Hydreionocrinus (?) *orbicularis* De Koninck will be found under *Cromyocrinus.*

*1884. **H. Wetherbyi** W. and Sp.—**Hydreionocrinus (Zeacrinus) arminger** (M. & W.) Wetherby, Journ. Cincin. Soc. Nat. Hist., iii, p. 5, figs. 7–10.—Kaskaskia gr. Pulaski Co., Ky.

CROMYOCRINUS Trautschold.

(Reconstructed W. and Sp.)

1867. Trautschold, Crin. jüng. Bergkalk bei Moskau, p. 19.
1879. Trautschold, Monogr. Kalkbr. von Mjatschkowa, p. 117.
1879. Zittel, Handb. der Palæont., i, p. 360.
 Syn. *Eupachycrinus* in part (W. and Sp.), Revision i, p. 133.
 Syn. *Hydreionocrinus* in part (De Koninck); Syn. *Agassizocrinus* in part (Worthen); Syn. *Poteriocrinus* in part (McCoy).

Placing *Cromyocrinus* as a synonym under *Eupachycrinus*, we found it impossible to uphold the genus upon any of the characters that had been pointed out by Trautschold. Wetherby has asserted (Journ. Cincin. Soc. Nat. Hist., iii, p. 8), that the genus was " well fitted to embrace all those species having three or more anals, a body composed of comparatively heavy, convex plates, and ten arms composed of a single row of joints." He further proposed to refer to *Eupachycrinus* all those species of this group having one or more anals, heavy rounded calyx plates, ten to fourteen arms, and these composed of a double series of interlocking plates. The biserial arm structure, which is only a higher form of the uniserial one, is as closely intermingled with the latter in the Russian form as in the typical *Eupachycrinus*, and also the plates of the calyx are heavy and convex in both groups. The only distinction of Wetherby upon which perhaps a separation of the species referred by us to *Eupachycrinus* might be established, is the number of azygous plates. We can separate the species with a single plate from those with three pieces, as proposed by White. A division of this kind, however, does not in the least affect *Cromyocrinus*, which, like the typical *Eupachycrinus*, has three azygous plates. But *Cromyocrinus* differs from the typical form of *Eupachycrinus*, in the form of the calyx, the relative size of the various plates, and in their mode of union. In all American species of *Eupachycrinus*, the form is depressed, more or less saucer-shaped, and the underbasals, which are very small and totally covered by the column, rest within a deep concavity together with the lower portions of the basals. The latter plates, and also the radials, are comparatively large, the underbasals small. In *Cromyocrinus* the calyx is globular, constricted at the upper end, the underbasals large, extending conspicuously beyond the column and forming a shallow cup.

The basals are so extremely large, the radials so comparatively small, that the former, together with the underbasals, frequently constitute over three-fourths of the cup, while in *Eupachycrinus* the same parts occupy not more than half that space. Besides, the plates of *Cromyocrinus* are united by syzygy, and not by ligamentous fossæ, as in most species of *Eupachycrinus.*

Our attention was directed to these facts by a species figured and described by De Koninck under the name of *Hydreionocrinus* (?) *globularis*, which in a somewhat higher degree has all the characters of *Cromyocrinus*, and at the same time resembles certain forms described under *Agassizocrinus.*

To *Agassizocrinus* have been referred two very distinct groups, the one almost always without column or even columnar attachment, with a large almost solid, subglobular or semiovoid underbasal cup, nearly truncate upper side, and small basals. The other, always attached to a column, with comparatively small underbasals, stretched out horizontally so as to form a five-rayed star, and with extremely large basals partly on the same plane with the underbasals. The latter species, which include *Agassizocrinus globosus* and *Agassizocrinus papillatus*, both described by Worthen, agree most closely with *Hydreionocrinus* (?) *globularis* De Koninck; *Poteriocrinus nuciformis* McCoy; *Cyathocrinus* (?) *sangamonensis* M. and W., all previously referred by us to *Eupachycrinus*, and all agree equally well with *Cromyocrinus simplex* from Russia. These species, we think, might be arranged under *Cromyocrinus*, and the only thing which prevented us from doing so before, is the similarity with Trautschold's two other species (*Cromyocrinus geminatus* and *C. ornatus*), which in their arm structure and general form approach *Epachycrinus;* while they agree in other points with *Cromyocrinus simplex.*

Cromyocrinus is closely allied to *Agassizocrinus*, to which it holds a similar position as *Pentacrinus* to *Antedon.* We doubt if *Cromyocrinus* ever became detached from its column, while all species of *Agassizocrinus* lose their column comparatively early.

Generic Diagnosis.—Dorsal cup globular, constricted above; composed of heavy plates; sometimes (perhaps always) united by syzygy.

Underbasals comparatively large, plainly visible beyond the column, horizontally arranged and forming a sharply delineated star, or sometimes a very shallow cup with a slight depression for the attachment of the column; suture lines well defined. Basals large; generally as high or higher than wide; three of them equal, hexagonal; the two adjoining the azygous side heptagonal, larger and of a different form.

Radials all pentagonal; the lateral faces often so short as to give to the plates a trigonal outline; their outer faces abruptly depressed or rounded off toward the brachials; upper side straight, facing upward; articular ridge well developed and occupying the full width of the plate. The right posterior radial narrower than the others, its lower left side disturbed by the azygous piece. The azygous plate is very large, placed in a sloping position, its two lower sides resting between two basals, its left side against the adjoining radial. The small truncate upper side supports the first plate of the ventral sac, the right side faces the anal plate, which is always considerably smaller, and extends beyond the limits of the radials. Brachials one or two; short; laterally touching their fellows of adjoining rays. Arms 5 to 10 or more; heavy, composed of short quadrangular joints, which change into cuneate pieces and in some species interlock. Arm furrows wide; pinnules strong. Articulation between radials and brachials and between the lower arm joints by transverse ridges and fossæ.

Ventral sac imperfectly known, but evidently short. Column small, circular; axial canal minute.

Geological Position, etc.—*Cromyocrinus* is found in the upper portion of the Subcarboniferous of Russia, England, Scotland, Belgium, and of the United States.

We place here the following species :—

1867. **Cromyocrinus geminatus** Trautschold. Referred by us, Rev., i, p. 138, to **Eupachycrinus.**

*1873. **C. globosus** (Worthen), **Agassizocrinus globosus**, Geol. Rep. Illinois, vol. v, p. 557, Pl. 21, fig. 12.—Kaskaskia gr. Chester, Illinois.

*1858. **C. globularis** (De Koninck), **Hydreionocrinus** (?) **globularis,** Memoirs de Paléont., p. 21, Pl. 2, figs. 1–4.—Referred by us, Rev. i, p. 138, to **Eupachycrinus.**—Upper part of Subcarboniferous. Near Glasgow, Scotland.

*1849. **C. nuciformis** (McCoy), **Poteriocrinus nuciformis**, Ann. and Mag. Nat. Hist. (Ser. ii), not **P. nuciformis**, Goldfuss (Fischer); also 1854, Contrib. Brit. Palæont. by Sedgwick, p. 116.—Subcarboniferous. Derbyshire, England.

1879. **C. ornatus** Trautschold. Referred by us, Rev., i, p. 138, to **Eupachycrinus.**

*1867. **C. papillatus** (Worthen), **Agassizocrinus papillatus,** Bull., i, Ill. St. Mus. Nat. Hist., p. 36; also Geol. Rep. Ill., vii, Pl. 29, fig. 17.—Kaskaskia gr. Monroe Co., Ill.

*1861. **C. sangamonensis** (M. and W.), **Cyathocrinus** (?) **sangamonensis**). Referred by us, Rev., i, p. 138, to **Eupachycrinus.**

1867. **C. simplex** Trautschold (Type of the genus). Formerly referred by us to **Eupachycrinus.**

EUPACHYCRINUS M. and W., Rev., i, p. 133.

(Restricted, W. and Sp.).

Accepting the genus *Cromyocrinus*, we have to consider only those species in which the cup is depressed or saucer-shaped, with small underbasals hidden from view and placed at the end of the basal concavity. These species, however, are divisible again into two groups: a, species with three azygous plates within the dorsal cup, *i. e.*, the typical form of *Eupachycrinus*, and: b, species with a small anal plate, partly extending into the equatorial regions, for which White proposed the genus *Ceriocrinus*. Accepting also this division (see *Ceriocrinus*), and admitting into *Eupachycrinus* such species as "*Cromyocrinus*" *gracilis* Wetherby, which has but five arms, and *Eupachycrinus spartarius*, Miller, with fourteen arms, we must modify our former generic formula so as to admit species with five to fifteen arms in place of ten, as we had previously given it. Thus restricted, *Eupachycrinus* is a strictly American genus, embracing only the following species: *Eupachycrinus Bassetti* Worthen, *E. Boydii*, *E. crassus*, Meek and Worthen, *E. formosus* Worthen, *E. orbicularis* (Hall), *E. quatuor-decim-brachiatus* (Lyon), *E. subtumidus* Worthen, *E. tuberculatus* M. and W., and *E. verrucosus* White, all previously reported, and perhaps also *E. platybasilis* White, which is very imperfectly known, and may be a *Zeacrinus*.

We also place here:—

1882. **Eupachycrinus asperatus** Worthen, Bull. i, Ill. St. Mus. Nat. Hist., p. 34; also Geol. Rep. Illinois, vii, p. 311, Pl. 29, fig. 4.—Kaskaskia gr. Monroe Co., Illinois.

*1880. **E. gracilis** (Wetherby), **Cromyocrinus gracilis**, Journ. Cincin. Soc. Nat. Hist., p. 4, Pl. 16, figs. 2 a, b, c.—Kaskaskia gr. Pulaski Co., Ky.

*1847. **E. maniformis** (Shum.), **Zeacrinus maniformis.** This species was referred by us Rev. i, p. 117, to **Scytalocrinus.**

* **E. Moorei** (Whitfield), **Zeacrinus Moorei,** Paleont. Ohio, vol. iii, Pl. 11, figs. 6, 10.—Coal measures. Hocking Co., O. (not published).

1882. **E. monroensis** (Worthen), Bull. i, Ill. St. Mus. Nat. Hist., p. 34; also Geol, Rep. Ill., vii, p. 312, Pl. 19, fig. 16.—Kaskaskia gr. Monroe Co., Illinois.

1879. **E. spartarius** S. A. Miller, Journ. Cincin. Soc. Nat. Hist. (April), Pl. 8, fig. 2.—Kaskaskia limest. Pulaski Co., Ky.

Syn. **E. germanus** S. A. Miller, ibid., Pl. 8, fig. 3.

TRIBRACHIOCRINUS McCoy.

1847. McCoy, Ann. and Mag. Nat. Hist., xx, p. 228.
1859. Pictét, Traité de Paléont., vol. iv, p. 321.
1884. F. Ratte, Proceed. Linnæan Soc. of New South Wales, vol. ix, Part 4.

(Diagram, Pl. 6, fig. 5).

This genus was originally proposed for a single specimen from the Subcarboniferous of Australia. According to McCoy, it differs from *Cyathocrinus* and allied genera by having only three arms. The cup is described as cupuliform, large, composed of three plates in the proximal ring, 5 plates in the succeeding one, followed by 1 × 3 radials, 3 interradials, and one or two anal plates. A similar explanation of the plates has been given lately by Mr. Ratte, who described another species in which "the second radials," the brachials according to our terminology, were preserved. Mr. Ratte had the kindness to send us an excellent cast of the type specimen, examination of which leads us to infer that the third ring of plates in the calyx was composed of seven pieces, of which five were radials, the two others azygous plates, but that none of them are interradials. In three of the radials, the articulating faces form a straight horizontal line, and only these plates are apposed by regular brachials, the two others, those of the two antero-lateral rays being angular and higher at their distal ends. The general outline of the two last mentioned plates, indicates that they are compound plates, each representing a radial and a bifurcating brachial, which probably became anchylosed. They evidently supported two arms, one at each side; while the three radials with articulated brachials apparently bear but a single arm like *Cromyocrinus simplex* Trautchold. Ratte observed in *Tribachiocrinus corrugatus* along the ventral surface between the brachials, "the casts of very small plates, irregular in shape, which doubtless belong to the so-called voûte (vault), or outer part covering the calyx as in *Rhodocrinus*, for instance." We seriously doubt if these plates, which he figures on Pl. 68, fig. 2, are any such thing as vault plates; we believe if they are plates at all, that they formed a part of the disk, and as such were covering pieces. The radials enclose the azygous plate proper and an anal piece as in most of the Poteriocrinidæ. *Tribachiocrinus* is not such an aberrant genus, as it was supposed to be. It is closely allied to *Cromyocrinus* and *Agassizocrinus*, and like them has large basals, comparatively small radials, and an unusually large azygous plate, followed by the anal piece and proximal plate of the ventral tube. It differs, however, from both genera in the number of underbasals, and the peculiarities in the radial regions which have been mentioned.

Revised Generic Diagnosis.—Dorsal cup globose; composed of heavy plates. Underbasals three, comparatively large; two of them larger than the other, but not of equal size; the smaller piece placed in a vertical line with the anterior radial (Pl. 6, fig. 5). Basals five, extremely large, very irregular in form; the posterior one heptagonal and larger than any of the rest; that to the left pentagonal; the three others hexagonal. The upper side in four of the plates is angular, in the other truncate, supporting the right postero-lateral radial.

Radials five; irregular in form and size, the postero-lateral one considerably smaller than the others. The two posterior radials as well as the anterior one pentangular, truncate above, and they support a short subquadrangular brachial; the two antero-lateral ones hexagonal, angular above, supporting on each side an arm. The line of articulation between the three former radials and their respective brachials is widely gaping, and the mode of articulation similar to that of all later Poteriocrinidæ. The brachials, although short, are twice as wide at their union with the radials as along their upper ends, which are truncate, moderately concave, each supporting a single arm. The two other radials, which have angular upper faces, are slightly constricted along their upper ends so as to indicate an anchylosis of brachials and radials.

Nothing is known of the ventral surface except imperfect impressions of small pieces. The azygous plate is unusually large, subquadrangular or trapezoidal; placed obtusely between the posterior basal and the right postero-lateral radial; its upper angle, which extends almost to the top of the radials, is slightly truncated and supports the ventral tube, its left upper side abuts against a large subquadrangular anal plate. Column apparently small and circular.

1847. **Tribrachiocrinus Clarkei** (Type of the genus) McCoy, Ann. and Mag. Nat. Hist., Vol. XX, p. 228, Pl. 12, Figs. 2, a.b.c.-Pictet 1857, Traite de Paleont., Vol. IV, p. 321.—Carboniferous.—Australia.

1884. **T. corrugatus** Ratte, Proceed. Linnean Soc. of New South Wales, Vol. IX, Pt. 4.—Carboniferous.—Australia.

b. *Graphiocrinites.*

GRAPHIOCRINUS De Koninck, Rev. i, p. 121.

Graphiocrinus has a bilateral symmetry, and is in some respects higher developed than the preceding genera, owing to the absence of the azygous piece. It has only an anal plate, and this is small and placed between the radials, resting upon the truncate upper side of the posterior basal. The ventral sac is cylindrical, and in *Graphiocrinus rudis* composed of longitudinal rows of subquadrangular pieces. We have not been able to examine the tube in other species, and hence are not aware whether the arrangement of these plates is of generic value. The species heretofore referred to *Graphiocrinus* have but a single brachial and ten arms; we have, however, in our collection an undescribed species with only five arms.

No additional species have been described.

BURSACRINUS M. and W., Rev. i, p. 123.

Syn. *Synyphocrinus* Trautschold, Bull., 1880.

In a paper "Ueber *Synyphocrinus*," Trautschold described a new species from Moscow, for which he proposes the above generic designation. He asserts that it differs from *Poteriocrinus* and allied genera in having "pentagonal, roof-like second radials, and these provided along the ventral side with two thorn-like processes, separated by the tentacle furrow;" that the third radials had similar processes and re-entering angles, overlying and covering the roof of the preceding plate; that the upper truncate side supported two bifurcating plates; that the species had no pinnules, and that the vault rested upon the thorn-like extensions of the third radials. We think Trautschold misunderstood his specimen. From his own figures and descriptions it is evident that the calyx, as in other Fistulata, contained a single radial, and that all succeeding plates were free, and true arm plates. His "second radial" is grooved for the reception of the "tentacle furrow," and, as shown by its form, a regular bifurcating plate, his remarkable "third radial" represents the two proximal arm plates, placed aside of each other, given off from the plate below. That pinnules were present in this species is shown even by the figure in which their faces are plainly represented. The processes at the inner side have no generic value, they are in connection with the articular faces of the plates, and are found, more or less, in all later Poteriocrinidæ. Prof. Trautschold overlooked the only important distinction between his form and *Poteriocrinus*. His species has a single anal plate within the dorsal cup, while *Poteriocrinus* has three. However, in this character *Synyphocrinus* resembles *Graphiocrinus*, and especially the subgenus *Bursacrinus*, which has the same general form, a similar funnel-shaped underbasal cup, and also branching arms.

It is possible that *Poteriocrinus meekianus* Shum. (Swallow's Geol. Rep. Missouri) is a *Bursacrinus*, but it may be a *Barycrinus*. Only the dorsal cup is known.

Additional species :—

*1881. **Bursacrinus cornutus** (Trautschold), **Synyphocrinus cornutus**, Bull. Moscow, Ueber **Synyphocrinus**.—Berg-Kalk. Mjatschkowa, Russia.

(?) Subgen. **PHIALOCRINUS** Trautschold, Rev., i, p. 124.

CERIOCRINUS White (not Koenig).[1]

(Emend. W. and Sp.).

1880. White, U. S. Geol. Surv. under Hayden for 1878. Paleont., Nos. 2–8 (Author's Ed., p. 12).
Syn. *Eupachycrinus* (in part), W. and Sp., 1878; M. and W., 1873.
Syn. *Eriosocrinus* (in part), White, 1879.

Ceriocrinus is very interesting as representing a link between the unsymmetrical *Eupachycrinus* and the symmetrical *Erisocrinus*. The three are very similar, and some of the species cannot be separated even specifically, unless the azygous side is exposed. We were at first inclined to follow Meek and Worthen in placing species with one and three anal (azygous) plates under *Eupachycrinus*, which has three in its typical form, and to separate those only which have no azygous plates within the dorsal cup. Our way of disposing of this question was contrary to the rules laid down by ourselves among other groups, but we took it to be a case of rapid and extravagant development, and as such possibly only of specific value. A similar view, but in a somewhat different direction, was taken by Dr. White, who placed in his *Ceriocrinus* species having an "anal plate" between the radials (none below), together with species in which a similar plate is supported by the radials (beyond the limits of the dorsal cup), and he ranked *Ceriocrinus* as a subgenus of *Erisocrinus*.

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[1] Koenig's genus has not been accepted (see De Loriol, Monogr. des Crin. Foss. de la Suisse, 1877, p. 61).

We are not satisfied whether the piece resting *upon* the radials (White's fig., 5 a) is equivalent to the one *between* the radials (his fig., 5 c), it is at least possible that the former is the anal plate, the latter a plate of the tube, or, as it is generally called, the third anal plate. We, therefore, cannot agree with White in considering the two forms generically identical, and much less specifically. If the difference in the two specimens was to be explained by individual development, that perhaps the anal piece had been resorbed in the adult, the specimens should differ in size, which is not 'the case. Throughout the coal-measures we find both forms side by side and of nearly equal size, a certain proof that the modification took place in the genus, and not in the individual. We must therefore either separate the two forms generically, or unite both with *Eupachycrinus.*

We stated under *Eupachycrinus* that we separate from that genus all species with a single azygous plate, and these we place under *Ceriocrinus.* Contrary to White, however, we exclude those species in which that plate rests upon the radials, which we place under *Erisocrinus.* Whether *Erisocrinus* and *Ceriocrinus* are full genera or only subgenera of *Eupachycrinus*, or the latter two of *Erisocrinus*, is a question which we leave open.

Ceriocrinus occupies the same relative position to *Graphiocrinus* as *Zeacrinus* to *Woodocrinus*, and as *Eupachycrinus* to *Scytalocrinus*, their differences being more of degree than of kind.

We refer to *Ceriocrinus* the following species :—

*1875. **C. Craigii** (Worthen), **Eupachycrinus Craigii**, Rev. i, p. 138.

*1873. **C. fayettensis** (Worthen), **Eupachycrinus fayettensis**, Rev. i, p. 138.

1866. **C. inflexus** (Geinitz), **Cyathocrinus inflexus**, Carbon. and Dyas in Nebraska, p. 62, Pl. 4, fig. 20; White, 1876, **Scaphiocrinus carbonarius** (not M. and W.). Powell's Rep. Geol. Uinta Mts., p. 89; White 1880, **Ceriocrinus inflexus**, 12th Ann. Rep. Terr., by Hayden for 1878 (author's ed., p. 127).—Carboniferous. Grand and Green River. Utah and Nebraska.

*1858. **C. hemisphericus** (Shum.), **Scaphiocrinus** (?) **hemisphericus**, Trans. St. Louis Acad. Sci., vol. i, p. 221. Meek 1872, Final Rep. on Nebraska, p. 147, Pl. 5, Fig. 4, and Pl. 7, fig. 1; also Geol. Rep. Ill., iii, p. 561, Pl. 24, fig. 5.—Carboniferous. This species we took (Rev. i, p. 138) to be a synonym of **Eupachycrinus Craigii**, but, if Meek's identification is correct, it is a good species. The plates, which in the latter are strongly spiniferous, are in the other but little convex.

1880. **C. planus** (White), **Erisocrinus planus** (Type of the genus), Proc. U. S. Nat. Mus., vol. ii, p. 257, figs. 6–7. White 1880, **Erisocrinus (Ceriocrinus) planus**, 12th Ann. Rep. Terr., by Hayden, for 1878, Author's copy, p. 127, Pl. 35, fig. 5 c (not 5 a = **Erisocrinus** White).—Coal measures. Humbold River, Ky.

c. *Erisocrinites.*

ERISOCRINUS Rev. i, p. 139.

Admitting *Ceriocrinus*, we place under *Erisocrinus* all species in which no azygous plates are represented at the dorsal side, but we also include those in which a plate of the ventral tube rests upon the radials. In all probability was the latter piece always present in this genus. The structure of the arms is the same as in *Encrinus* and *Eupachycrinus.*

The only new species to be added in the list is:

*1880. *Erisocrinus Whitei* W. and Sp., *Erisocrinus* (*Ceriocrinus*) *planus* (in part). White 12th Ann. Rep. Terr. by Hayden for 1878 (Author's copy, p. 127, Pl. 35, Fig. 5a (not 5c = *Ceriocrinus planus*). Distinguishing the specimen Fig. 5c specifically, we propose the above name for the other to avoid confusion.

STEMMATOCRINUS Trautschold, Rev. i, p. 141.

In Part I, we separated *Stemmatocrinus* from *Erisocrinus* only subgenerically, from the fact that it agrees with that genus in all its particulars, except that the underbasals consist of a single plate instead of five in the other, which we explained by anchylosis. This explanation was doubted by Carpenter, who in the Chall. Rep., p. 152, says : " the plate in question appears to me much more truly represented by the central pentagonal piece on which the basals rest, and it is obviously what Schultze calls 'eine fünfseitige aus der Erweiterung des obersten Säulengliedes gebildete Platte.' " And again: "the analogue of the development of the other calyx plates indicates that they (the underbasals) are primitively five separate plates like their homologues in the apical system of Ophiurids and starfishes; and a theory which would homologize them with a plate that first appears as a simple ring seems to me to run counter all true notions of morphology." We confess that we do not understand Carpenter's argument, for we believe *Stemmatocrinus* had primitively five plates, which were united by anchylosis leaving no vestige of the sutures. Similar cases of anchylosis among basals and underbasals have been observed among other Palæocrinoidea and even among Neocrinoidea. In one of the two species of the recent genus *Rhizocrinus*, the basals are distinctly divided, in the other united by anchylosis. In *Platycrinus* it is absolutely impossible to discover a suture between the basals, the anchylosis between the plates is complete, and only in comparatively few species the place of union is still indicated by a depression. Such is the case also in *Dolatocrinus* and *Stereocrinus.* In *Agassizocrinus* an anchylosis takes place between the underbasals, all suture lines disappear in the older specimens. In *Eupachycrinus ornatus* and *Eupachycrinus gemmiformis*, which occur in the same bed with *Stemmatocrinus cernuus*, the sutures are frequently not visible, and the plates apparently constitute a solid disk which in form and proportions resembles that of *Stemmatocrinus.*

STEMMATOCRINUS TRAUTSCHOLDI[1] nov. sp.

(Pl. 9, figs. 7 and 8.)

Of large size. Dorsal cup subglobose ; plates heavy. Underbasals of medium size, anchylosed, forming a solid pentangular plate with concave sides, the latter with a somewhat waving outline. The plate is slightly convex, except the columnar attachment which is rather deeply impressed. There are absolutely no sutures visible either upon the dorsal aspect or upon the inner floor. The centre is perforated by a minute star-shaped canal, with rays directed radially. Basals about as long as wide, pentagonal in outline, but really hexagonal, the two lower sides having together the length of the four others; their upper sides convex.

Radials once and a half to twice as long as wide; concave along their basi-radial suture, along their distal side slightly excavated. The articular faces are directed upward and occupy nearly the full width of the plates. The articulation with the brachials is by a transverse ridge with a central canal and shallow fossæ. Brachials two, both extremely short but deep. They are followed by several short, cuneate pieces. The upper part of the arms is not known.

The specimens show traces of interradial plates resting against the inner edges of two radials, of which the places of attachment are plainly visible (Pl. 9, fig. 8), and detached plates were placed aside of them.

Geological Position, etc.—From the Keokuk limestone near Nashville (White's Creek), Tenn. The original specimens, some thirty in number, are in our collection.

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[1] In honor of Prof. Trautschold of Moscow, Russia, the author of the genus, who had the kindness to send us a beautiful series of the Mjatschkowa Crinoids.

FAMILY XXIII.—**ENCRINIDÆ** Pictet.

J. S. Miller refers the genus *Encrinus*, together with *Pentacrinus*, to his Articulata, *Poteriocrinus* to his Semiarticulata. Zittel, and after him De Loriol, to the Articulata of Müller; while they refer the closely allied *Poteriocrinus* to Müller's Tessellata. The mode of articulation is identical in *Encrinus* and the later Poteriocrinidæ, as pointed out in our general remarks on the Fistulata, and our notes on the Poteriocrinidæ. A separation, therefore, in the sense of either Miller or Müller, cannot be carried out practically. A ventral covering was never found to be preserved in *Encrinus*, and as the same thing happens to be a rule among all fossil Neocrinoidea, it was postulated that this genus had an open perisome, and as such was a Neocrinoid. However, the ventral surface is also unknown among the Poteriocrinidæ, which are universally regarded as Palæocrinoids. Neither is the absence of azygous plates in the dorsal cup exclusively found among Neocrinoidea—we need only allude to *Codiacrinus*, *Ceriocrinus* and *Erisocrinus*—nor the presence of two brachials (three radials), which was pointed out by Carpenter a good distinctive character. The latter is a very common occurrence among the Poteriocrinidæ, among which we failed even to make it a generic distinction. We are willing to admit that *Encrinus* constitutes a transition form toward the Neocrinoidea, it is even possible that in the adult the interradials became partly or wholly resorbed, but it is otherwise so closely connected with the Poteriocrinidæ that we must regard it a Palæocrinoid or place also the Poteriocrinidæ among the Neocrinoidea.

Pictet, and after him Dujardin and Hupé, placed *Encrinus* under the Pycnocrinidées, which they subdivided into *Encriniens*, *Apiocriniens* and *Pentacriniens*. This division was accepted by De Loriol in his work on the Swiss Crinoids, but in his later monograph on the Crinoids of France he followed Zittel, who made it the type of a distinct family of the Neocrinoidea. All writers preceding us, with the exception of Zittel, described *Encrinus* with 3 × 5 radials, although the two upper plates are laterally free, and morphologically and functionally identical with the brachials of the Poteriocrinidæ.

We agree with De Loriol and Zittel that Von Meyer's genus *Chelocrinus*, which is based on species having a second bifurcation in the arms, cannot be sustained. His *Dadocrinus*, however, seems to be a good generic form, and will be treated by us as such. We separate from the Encrinidæ Picard's *Encrinus Beyrichi*, which we refer to the Belemnocrinidæ. Von Meyer's genus *Calathocrinus*, which some writers assert to be identical with *Encrinus*, is known only from a single imperfect specimen.

ENCRINUS (Lamarck), J. S. Miller.

1816. Lamarck, Descr. des Animaux sans vertebrés (Ed. i), vol. ii, p. 435.
1821. Miller, A Natural History of the Crinoidea, p. 37.
1823. Schlotheim, Nachtr. z. Petrefactenkunde, p. 335.
1826–33. Goldfuss, Petrefacta. Germ., vol. i, p. 177.
1857. Pictet, Traité de Paléont. (Ed. ii), vol. iv, p. 337.
1857. Beyrich (in part), Ueber die Crinoid. d. Muschelkalk (Berl. Acad. d. Wissenschaften).
1876. Quenstedt, Petrefactenk. Deutschlands, vol. iv, p. 455.
1877. De Loriol, Monogr. Crin. Foss. de la Suisse, p. 7.
1879. Zittel, Handb. d. Palæontologie, i, p. 383.
1882. De Loriol, Paleont. Francaise (Ser. I), Crinoidea, p. 6.

Syn. ***Entrochus*** and ***Trochites*** Agricola; ***Chelocrinus*** and perhaps ***Calathocrinus*** v. Meyer, (?) ***Tetracrinus*** Cotullo, ***Flabellocrinus*** Klippstein, and (?) ***Cassianocrinus*** Laube.

Generic Diagnosis.—Dorsal cup regularly pentamerous; short, saucer-shaped; composed of 5 underbasals, 5 basals and 5 radials, all equal in size and form; there being no azygous plates.

Underbasals minute, rhomboidal, forming together a five-rayed star; entirely covered by the top stem joint. Basals small, hexagonal, for the greater part hidden by the column. They rest with their lower sides between two underbasals, are laterally united, support with their sloping upper sides the radials, and form jointly a pentagon with almost straight sides. The radials are large, subquadrangular; their distal sides once and a half as wide as their lower or proximal sides; they are thick, heavy, the faces toward the basi-radial suture somewhat hollowed out, showing shallow fossæ, while their lateral faces indicate a syzygial union.

Brachials two, the first quadrangular, the other pentangular; they are heavy plates with straight lateral faces by which they abut against the apposed faces of adjoining plates. The upper plate is axillary, supporting two arms, which either remain simple, or of which one or both from the second plate branch again. Arms massive, composed of short transverse plates, which in their upward arrangement change from quadrangular pieces with strictly parallel sides to cuneiform and gradually interlocking plates ; some of them, however, possess a fully developed biserial arm structure. The union between radials and first brachials, and also between the axillaries and proximal arm plates is by articulation, the apposed faces having highly developed facets with transverse ridges, and a central canal and fossæ. The two brachials are united by syzygy, as also the two proximal arm joints.

In *Encrinus*, the inner floor of the dorsal cup is grooved by five primary canals, which, as they pass outward, bifurcate within the basals, and the ten secondary canals thus formed proceed to the radials, and thence after dividing again to the arms. These grooves which are by no means restricted to *Encrinus* or to the Neocrinoidea, are, according to P. H. Carpenter (his paper on the Oral and Apical system of Echinoderms, Quart. Journ. Microsc. Sci. London, 1880, p. 362), passages for the fibrillar cords going out from the interradial angles of the chambered organ.

Nothing is known of the ventral surface, except in a young specimen in which we thought to observe a few plates of a ventral tube. The interradial plates, owing to the large size of the articular facets, must have been small at any time, and possibly were absorbed in the adult. Column composed of circular joints without cirrhi.

Geological Position, *etc.*—Muschelkalk, Trias. Germany and Switzerland.

We recognize the following species :—

1847. **Encrinus aculeatus** v. Meyer, Leonh. Bronn's Jahrb., p. 576; also Palæontogr. i, 1851, p. 262, Pl. 32, fig. 1; also Beyrich 1857, Crin. des Muschelk., p. 38, Pl. 1, figs. 16 a, b.—Muschelkalk, Trias. Upper Silurian, Germ.

1850. **E. Brahlii** Owerweg, Zeitschr. d. deutsch. geol. Gesellschaft, vol. ii, p. 6; also Beyrich, 1857, Crin. des Muschelk., p. 39, Pl. 2.—Muschelkalk, Trias. Rüdersdorf, Germ.

1856. **E. Carnalli** Beyrich (**Chelocrinus Carnalli**), Zeitsch. d. deutsch. geol. Gesellsch. p. 10; also Leonh. Bronn's Jahrb. (1856), p. 28.—Muschelkalk, Trias. Rüdersdorf, Germ.

1877. **E. Grephini** De Loriol, Crinoides Foss. de la Suisse, p. 12.—Muschelkalk. Meyenbühl, near Basle, Switzerl.

1816. **E. liliiformis** Lamarck, Descr. des Animaux sans vertèbres, 1 édit., vol. ii, p. 435, Schlotheim 1820, Petrefactenk., p. 335.—Agassiz, 1835, Prodr. Mem. Soc. Sci. nat. de Neuchatel, vol. i, p, 195.—Dujardin (in Lamarck), 1840, Descr. des Animaux sans vertèbres, 2me édit., vol. ii, p. 651.—Desor, 1845, Notice sur les Crinoides Suisses, p. 3; Bull. Soc. Sci. nat. de Neuchatel, vol. i, p. 211.—Pictet, 1857, Traité de Paléont., 2me édit., vol. iv, p. 337, Pl. 102, fig. 4.—Beyrich, 1857, Ueber die Crin. des Muschelkalkes, p. 1, Pl. 1, fig. 1–12.—Strombeck, 1856, Ueber Missbildungen von **E. liliiformis**, Palæontographica, vol. iv, p. 168, Pl. 31.—Dujardin et Hupé, 1862, Suites à Buffon Echinoderms, p. 164.—Ooster, 1865; Syn. des Echin. des Alpes Suisses, p. 10; Moesch, 1867, der Aargauer Jura, pp. 26, 27–30 (Beiträge z. Geol. Karte der Schweiz, 4te Liefer.); Greppin, 1870, Descr. géol. du Jura bernois, p. 13.—Moesch, 1874, der südliche Aargauer Jura, p. 4, Anhang, p. 6.—Quenstedt, 1876, Petrefactenk. Deutschl., vol. iv, p. 455, Pl. 106, figs. 143–184.—Bronn, Klassen des Thierreichs (Actinozoa), vol. ii, Pl. 29, fig. 3.—De Loriol, Crinoid. Foss. de la Suisse, 1877, p. 9.—Zittel, Handb. d. Palæont., i, p. 383.—Muschelkalk Trias. Germany and Switzerland.

Syn. **Lily encrinite**, 1808, Lamarck, Organ. Remains, vol. ii, p. 14, figs. 1–3.

Syn. **Encrinites moniliformis** Miller, 1821, A Nat. Hist. of the Crinoidea, p. 37, Pl. 1, 2, 3; also Goldfuss, 1826–33, Petrefacta Germ., vol. i, p. 177, Pl. 54.

Syn. **Pentacrinus entrocha** Blainville, 1834, Manual d'Actinologie, p. 257, Pl. 28, fig. 2, and ibid., p. 657.

Syn. **Encrinus entrocha** D'Orbigny, 1839, Monogr. des Crinoid., Pl. 18; also D'Orbigny, 1850, Prodrome, vol. i, p. 178.

1835. **Encrinites Schlotheimi** Quenstedt, Wiegm. Arch., ii, p. 227, vol. 4, fig. 1; also 1852, p. 614; also **Chelocrinus Schlotheimi** H. v. Meyer, 1837, in Leonh. Bronn's Jahrb., p. 316, and Mus. Senkenb., ii, 1837, p. 262, vol. 16, fig. 9; also Bronn, Lethæa (Edit. 3), Bd. iii, 1851, p. 48, vol. 13, fig. 3.—E. Beyrich. Ueber die Crinoid. des Muschelk., 1857, p. 34, vol. i, fig. 13.—Muschelkalk, near Göttingen, Germany.

Syn. **Chelocrinus pentactinus** H. v. Meyer, 1837, Leonh. Bronn's Jahrb., p. 316; also 1837, Mus. Senkenb., ii, p. 262, vol. 16, fig. 8; also L. v. Buch, 1848, in Leonh. Bronn's Jahrb., p. 690.

Syn. **Encrinus liliiformis**, Ueber Missbildungen, Strombeck, 1849, Zeitschr. d. deutsch. geol. Gesellsch., i, p. 163; 1855, Palæontogr., iv, p. 177.

Syn. **Encrinus pentactinus**, Bronn, 1837, Leonh. Bronn's Jahrb., p. 30, vol. 2, 1851; also Lethaea Geogn. (Ed. 3), Bd. iii, p. 47, Pl. 13, fig. 1.—Also Geinitz, 1838, Leonh. Bronn's Jahrb., p. 530.

DADOCRINUS v. Meyer.

1847. v. Meyer, Leonh. Bronn's Jahrb., p. 575.

1851. v. Meyer, Palæontographica, i, p. 266.

Syn. *Encrinus* (in part), L. v. Buch, Bericht Berl. Acad., 1845, p. 27; also Beyrich, Ueber Crinoideen des Muschelk., p. 42; also De Loriol, 1877, Crin. Foss. de la Suisse, p. 8; also Zittel, Handb. d. Palæont., i, p. 383.

This genus has not been accepted by Beyrich, Zittel; nor De Loriol. It was proposed by H. v. Meyer for a species previously described by L. v. Buch under the name of *Encrinus gracilis*.

The latter has a turbinate calyx, underbasals (observed by Beyrich not by H. v. Meyer), an apparently round stem; ten arms which are not very closely folded, composed of cuneiform flat joints, and pinnules which are alternately arranged. The totally different form of the dorsal cup seems to us sufficient to warrant the generic separation. L. v. Buch's typical specimen came from Recaoro, Italy, and was supposed by Beyrich to be identical with certain fragments which had been discovered in the Trias of Upper Silesia, too imperfect, however, for critical comparison. From this locality a more perfect specimen was found lately by Mr. H. Kunisch, who figured and described it in the Zeitschrift d. deutsch. geol. Gesellsch. Jahrg., 1883, under the title "Ueber den ausgewachsenen Zustand von *Encrinus gracilis* Buch." We cannot altogether agree with Mr. Kunisch in his views. The Silesian species is, in our opinion, essentially different from the Italian one. The column is pentagonal in place of circular; the arms rounded, angular at the outer face, and the pinnules are given off alternately from every second joint, every other one being united by syzygy; contrary to the typical species, which has flat arms, cuneiform joints, and of which every joint is pinnule-bearing. The distinctions are so obvious that a specific separation is necessary, and we propose for the Silurian species the name *Dadocrinus Kunischi.* To explain the diversity in the arm-structure by individual growth is at variance with the observations made upon recent as well as fossil Crinoids. We agree that the arms undergo important modifications in their growth, but we do not find cuneate arm joints turning into quadrangular ones, though frequently the opposite is the case; nor that single joints are undergoing segmentations and are uniting again by syzygy. The angles of the column in *Dadocrinus Kunischi* are directed interradially, thus proving theoretically the base to be dicyclic, which could not be ascertained from the specimen.

We propose the following:—

Revised Generic Diagnosis.—Form of dorsal cup obconical. Underbasals small, covered by the column; basals forming an elongate hexagonal cup. Radials comparatively smaller than in *Encrinus*, but yet twice as large as the basals. Brachials in number, form and articulation as in *Encrinus.* Arms long, uniserial, composed of single or compound joints, the latter united by syzygy; pinnules long, and placed far apart. Column round or pentangular, with or without cirrhi.

1845. **Dadocrinus gracilis** (L. v. Buch), v. Meyer, **Encrinus gracilis**, Bericht d. Berl. Acad., p. 27.—**Dadocrinus gracilis** H. v. Meyer (Type of the genus), 1847, Leonh. Bronn's Jahrb., p. 575; also Palæontogr., i, p. 266, Pl. 31, fig. 2 and Pl. 32, figs. 4, 5, 6; Pl. 31, figs. 9, 13; Pl. 32, fig. 7.—**Encrinus gracilis** Beyrich, Ueber die Crin. d. Muschelk., p. 42, Pl. 1, fig. 15.—Muschelkalk Trias. Recaoro, Italy.

*1884. **D. Kunischi** W. and Sp. Described and figured by Mr. Kunisch as **Encrinus gracilis**, Zeitschr. d. Deutsch. geol. Gesellsch., Jahrg., 1883, p. 195, with plate.—Muschelkalk. Upper Silesia.

FAMILY XXIV.—ASTYLOCRINIDÆ Roemer.

The Astylocrinidæ embrace only the genus *Agassizocrinus*, which Pictet referred to the Comatulidæ, Zittel to the Poteriocrinidæ. Roemer included in this family *Marsupites*. We place here provisionally the genus *Edriocrinus*, which, however, in all probability, forms a family by itself, being sessile in early life, and having no underbasals.

AGASSIZOCRINUS Troost.

(Pl. 5, fig. 17.)

1850. Troost, Journ. Am. Ass. Adv. Sci. Camb. Meeting, p 60.
1851. Owen and Shum., Journ. Acad. Nat. Sci. Phila. (n. ser.), vol. ii.
1853. Shumard, Marcy's Rep. Red River Exped., of Louisiana, p. 173.
1852. Owen and Shum., Geol. Rep. Ia., Wisc. and Minn., p. 597.
1858. Hall, Geol. Rep. Iowa, vol. i, Pt. ii, p. 684.
1873. Worthen, Geol. Rep. Illinois, vol. v, p. 556.
1874. Meek, Amer. Journ. Sci. (Ser. 3), vol. vii, No. 41, p. 484.
1879. Zittel, Handb. d. Palæontologie, i, p. 361.
Syn. *Astylocrinus*, 1854, F. Roemer, Leth. Geogn. (Ausg. 3), p. 229; also Dujardin and Hupé, 1862, Hist. natur des Zooph. Echin., p. 159.

The name *Agassizocrinus* appears in Troost's List of the Crinoids of Tennessee, but the genus was not defined until 1853, when Shumard, in Marcy's Report on the Red River Expedition, published Troost's MS. of *Agassizocrinus dactyliformis*, which he accompanied with a short generic description of his own. *Astylocrinus* was proposed by Roemer as late as 1855, when he described under the name *Astylocrinus lævis*, a nearly perfect specimen from a plaster cast, sent to him by Shumard's brother with Troost's name *Agassizocrinus dactyliformis* attached. There cannot be the least doubt as to the priority of *Agassizocrinus*, but it is probable that Roemer's specimen, which was Troost's type, is specifically distinct from the one figured by Shumard under Troost's name, and hence we recognize Roemer's specific name.

Detached plates of *Agassizocrinus* are found in great abundance throughout the Kaskaskia group, but perfect calices are extremely rare. The cause of this is perhaps explained by the mode in which the different plates are united with one another. Only the underbasals seem to have been united by common suture, and these, as a rule, are the only plates which are not found disconnected in the fossil. The apposed faces of the succeeding plates are vertically and horizontally provided with rather conspicuous ramifying furrows, which enter the surface of the plates (Pl. 5, fig. 17). The ramifications vary somewhat, even among corresponding plates, but those of apposed faces correspond with each other, and together form small tunnels, which branch once or twice, growing narrower at their outer ends. Between basals and underbasals there are generally three of these furrows to each plate; but they unite to one on entering the underbasal cavity, where they seem to communicate with certain pits or openings, which have been overlooked by previous writers.

The underbasals form an almost solid disk, with a shallow, cup-shaped inner cavity. The latter contains six deep pits or chambers, closed at the bottom, a central one surrounded by five others. These pits either contained the lower part of the chambered organ, or they indicate where the vessels extended down from the chambers into the larval stem. It is possible that the axial canals which descend from the body cavity were lodged in these chambers, together with the vessels of the latter, and this might explain the apparent communication of the pits with the radiating furrows above mentioned. But it may be possible, also, that the furrows lodged groups of ligamentous fibres, by which the union of the plates was rendered firmer and closer than it would be when only two smooth surfaces were apposed. The plates, however, as a general rule, are found to be disconnected, and the radials at their lateral faces possess fossæ, thus proving there existed a certain degree of mobility between the calyx plates generally. Similar ramifying furrows were discovered by us in the genus *Barycrinus* between the apposed articular facets of radials and brachials, plates which evidently were not united by a close suture.

Agassizocrinus in the earlier stages was attached by a column, but led a free life later on, when the scar to which the stem had been attached was gradually obliterated, so as to leave no traces behind. The secretion of calcareous matter extended over the greater part of the underbasal disk, which became more elongate, until at last the suture lines between the plates disappeared entirely, although in the young Crinoid these are well marked. Owing to the very considerable changes of form, which occur in the growing animal, it is extremely difficult to identify the species of this genus, and we fear that several of those described represent merely different stages of the same species.

Agassizocrinus globosus and *A. papillatus* Worthen have been referred by us to *Cromyocrinus;* his *A. hemisphericus*, in which the underbasals do not extend beyond the column, is either *Eupachycrinus* or *Scytalocrinus*, probably the latter.

Generic Diagnosis.—Form of calyx elongate, composed of massive plates, and containing a comparatively small visceral cavity.

Underbasals extremely large; obconical; almost solid; with a very small inner cavity. Young specimens have an articular scar for the attachment of a column, pierced by an axial canal; this, however, becomes obliterated soon after the Crinoid enters free life. The inner cavity lodges the chambered organ, and is provided with six deep pits, a central one surrounded by five others, which either constitute the chambers of this organ or their lower extensions.

Basals large, three of them hexagonal, two heptagonal, but they appear to be pentagonal and hexagonal, owing to the convex form of the two lower sides. The heptagonal plates enclose, and partly support, the azygous pieces, consisting of the azygous plate proper, which has a sloping position and is generally large, a smaller anal plate, and the first plate of the ventral tube. The size and form of the tube is not known, but it was evidently small, perhaps similar to that of *Cromyocrinus*, with which *Agassizocrinus* agrees in the arrangement of its azygous plates.

Radials unusually small; wider than high; the upper face truncate; they are all pentagonal, four of them of nearly equal size, the fifth one considerably smaller and of irregular form. The articular facets are on a level with the outer edges of the plates, they are somewhat extended inward, and pierced by a transverse axial canal. The articulation between calyx and arms is regularly bifacial, resembling that between the oval stem-joints of *Platycrinus.* The brachials are single, axillary, and abut laterally against each other. The arms are long, rather stout, rounded, and composed of short, cuneate pieces. Pinnules strong.

The mode of union between the plates of the calyx is variable.

The underbasals were united by a common suture, the lines of which in the adult Crinoid are completely obliterated. The basals possess, among each other, and where they meet the underbasals and radials, ramifying furrows along their faces, which, together with similar furrows on apposed faces, form tunneled passages, probably containing ligament; the lateral faces of the radials, however, are excavated for fossæ.

Geological Position, etc.—Restricted, so far as known, to the Kaskaskia group of America.

The following species have been described:—

1873. **Agassizocrinus carbonarius** Worthen, Geol. Rep, Ill., v, p. 566, Pl. 24, fig. 4.—Coal measures. Shelby Co., Ill.

1873. **A. chesterensis** Worthen, Geol. Rep. Ill., v, p. 558, Pl, 21, fig. 9.—Kaskaskia gr. Chester, Ill.

1851. **A. conicus** Owen and Shum., Journ. Acad. Nat. Sci. Phila. (n. ser.), vol. ii, p. 93, Pl. xi, fig. 6.—Geol. Rep. Iowa, Wisc., and Minn., p. 597, Pl. 5 b, fig. 6.—Meek and Worthen, 1873, Geol. Rep. Illinois, Pl. 21, fig. 8.—Kaskaskia limest. Chester, Illinois.

1858. **A. constrictus** Hall, Geol. Rep. Iowa, vol. i, p. 687, Pl. 25, fig. 10.—Kaskaskia gr. Chester, Illinois.

1850. **A. dactyliformis** Troost, Type of the genus. List Crin. Tenn. Cambr. Meet., p. 60; Shum. 1853, Marcy's Rep. Red River, p. 173.—Hall 1858, Geol. Rep. Iowa, vol. i, p. 685, with diagram.—Kaskaskia gr. Chester, Ill., and Crittenden Co., Ky.

1858. **A gibbosus** Hall, Geol. Rep. Iowa, vol. i, p. 686, Pl. 25, fig. 6.—Worthen 1873, Geol. Rep. Ill., v, Pl. 21, fig. 11.—Kaskaskia gr. Chester, Ill.

A. gracilis Troost is a catalogue name.

*1855. **A. lævis** (Roemer), **Astylocrinus lævis** (Second type of the genus), Leth. Geogn. (Ausg. 3), p. 229, Pl. 4, fig. 13.—Kaskaskia gr.

*1852. **A. occidentalis** Owen and Shum. (**Poteriocrinus occidentalis**), Journ. Acad. Nat. Sci. Phila. (n. ser.), vol. ii, p. 92, Pl. xi, fig. 5; also Geol. Surv. of Iowa, Wisc. and Minnes., p. 596, Pl. v *b*, fig. 4.—(Probably a young specimen of **A. gibbosus** Hall).—Kaskaskia gr. Chester, Illinois.

A. pentagonus Worthen, Geol. Rep. Ill., v, p. 556, Pl. 21, fig. 10.—Kaskaskia gr. Chester, Illinois.

1852. **A. tumidus** Owen and Shum., Journ. Acad. Nat. Sci. Phila., vol. ii, p. 90, Pl. xi, fig. 3; also 1852, Geol. Surv. of Iowa, Wisc. and Minnes., p. 595, Pl. v *b*, fig. 3.—Kaskaskia gr. Chester, Illinois.

(?) EDRIOCRINUS Hall.

1859. Hall, Pal. Rep. N. York, vol. iii, pp. 199 and 143.
1832. Hall, 15th Rep. N. York. St Cab. Nat. Hist., p. 115.
1838. Meek and Worthen, Geol. Rep. Illinois, vol. iii, p. 119.
1879. Zittel, Handb. d. Palæontologie, i, p. 350.
1883. P. H. Carpenter, Ann. and Mag. Nat. Hist. (May, 1883), p. 333.

Edriocrinus led a life similar to that of *Agassizocrinus*, being attached in its larval state, and free-floating in the adult. It differs from that genus, however, in having no underbasals and no stem, being simply attached by the basals. In its sessile state it resembles the recent genus *Holopus*, with which it also agrees in having an undivided base.

Generic Diagnosis, etc.—Sessile in its larval state; free-floating in the adult, being attached by the lower end of the basals.

Basals unusually large, elongate, closely anchylosed so as to show no suture lines at the outer face; internally, however, there are indications that the base might have been bisected. In the young animal the form of the base is irregular and linear, in the adult subglobose or deeply bowl-shaped, and the scar by which the animal was attached, becomes totally obliterated by heavy deposits of calcareous matter. Owing to this deposit the outer form of the base differs considerably from the form of the inner cavity, which grows gradually narrower toward the bottom, and frequently ends in a sharp point. The walls are massive at their lower parts, thin at the upper edge, which shows six excavated faces for the attachment of five radials and an anal plate.

Radials comparatively small, quadrangular, articular facet but slightly excavated, occupying the full width of the plates; provided with a transverse articular ridge. The anal plate is in line with, and has the length of the radials, but is narrower; it supports a small plate, but beyond that nothing is known of the anal apparatus. The structure of the ventral surface has not been observed.

The arms are broad at the base, composed of extremely short transverse pieces, of which ten or more occur between the first bifurcation. Nothing is known of pinnules, nor of the condition of the ventral furrow.

Geological Position, etc.—*Edriocrinus* occurs in the Helderberg group of America, in which portions of the basal cup are rather abundant.

1859. **Edriocrinus pocilliformis** Hall, Pal. Rep. N. York, iii, p. 121, Pl. 5, figs. 8–12; also 1868, Geol. Rep. Illinois, iii, p. 370, Pl. 7, figs. 5 *a*, *b*.—Lower Helderberg gr. Albany, New York and Perry Co., Mo.

1862. **E. pyriformis** Hall, 15th Rep. N. Y. St. Cab. Nat. Hist., p. 116, Pl. 1, figs. 23 and 24.—Upper Helderberg gr. Utica, New York.

1859. **E. sacculus** Hall, type of the genus. Pal. Rep. N. York, vol. iii, p. 143, Pl. 87, figs. 1–22.—Oriskany sandst. Cumberland, Maryland.

FAMILY XXV.—CATILLOCRINIDÆ W. and Sp.

The group of Crinoids for which we propose the name Catillocrinidæ consists only of the genera *Catillocrinus* and *Mycocrinus*, which have been distinctly separated by all previous writers. *Catillocrinus*, which was described by Meek and Worthen as closely allied to *Symbathocrinus*, was referred by Zittel and De Loriol to the Pisocrinidæ, which we regard as a mere subdivision of the Symbathocrinidæ. The form, when we include the arms, is similarly cylindrical, the arms rest likewise directly upon the first radials, and are composed of a single series of plates. *Pisocrinus* even has irregular radials, which is so characteristic of this family, but beyond that the two groups are quite distinct. *Mycocrinus*, according to Schultze, forms a family by itself. He took it to be a Crinoid without arms, which, in place of arms, he thought had been provided along the ventral surface with numerous ambulacral grooves. Zittel, and also De Loriol, have placed *Mycocrinus* among the genera which were said to be imperfectly known.

In the Catillocrinidæ, the calyx is composed of only two series of plates, and these are most remarkable for their extremely irregular form and distribution. The radials are massive, especially at the upper margins, where they are transversely truncated on the same plane all round. The radial plates differ in form and size. Those of the two antero-lateral rays, as a rule, are much larger than the three others, but, while at their upper margin they are from three to six times as wide as the others, all are at the basi-radial suture about equal in width. The anterior, and both postero-lateral rays, rarely possess more than one arm each, but in the two antero-lateral ones the arms are always numerous. Every arm articulates directly upon the truncate upper margin of the radial without the aid of axillary pieces, and remains simple from the base up. The arms are in contact all around the calyx, and are composed of a single series of very similar pieces. They connect with the inner cavity by a peculiar groove, which follows the truncate upper face of the radials. This groove contains the ambulacral canal and food passage, and there is underneath, separated by a solid partition, another groove, which near the inner margin penetrates the plate, and takes a distinctly downward course toward the inner cavity, which throughout this family is exceedingly small.

The ventral surface has not been observed, but there is sufficient evidence to prove that it was similar to that of the other Fistulata.

Catillocrinus has its closest affinities with *Calceocrinus.* The radials of the three anterior rays agree in form and distribution so closely with the radials of *Calceocrinus*, that we thought at first that it also possessed but three rays, and that the two irregular plates toward the posterior side were anals and not radials. This interpretation had to be given up when we found both these plates to be arm-bearing. In *Calceocrinus* the postero-lateral rays are entirely absent or transformed into anal plates ; while in *Catillocrinus* those rays are represented in a rudimentary form.

The Catillocrinidæ are meagre in forms and belong to the rarest Crinoids. They are restricted, so far as known, to the Devonian of Europe and to the Subcarboniferous of America.

CATILLOCRINUS Troost.

(Pl. 5, figs. 15, 15*a* and 16.)

1850. Troost, List. Crin. Tenn. Proc. Amer. Assoc. Ad. Sci., p. 60.
1860. Shumard, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.
1868. Meek and Worthen, Geol. Rep. Ill., vol. iii, p. 465.
1873. Meek and Worthen, Ibid., vol. v, p. 504.
1879. Zittel, Handb. d. Palæontologie, vol. i, p. 348.
1882. De Loriol, Paléontologie Française, Crinoids, vol. xi, p. 46.
Syn. *Nematocrinus* Meek and Worthen, 1866, Proc. Acad. Nat. Sci. Phila., p. 251.

Troost published the name *Catillocrinus* in his List of the Crinoids of Tennessee, without generic diagnosis. The first description was given in 1866, by Shumard, in a foot-note to his Catalogue of the Palæozoic Fossils of North America, from specimens of *Catillocrinus Tennesseæ.* He described the calyx as composed of three series of plates: the "basals" which were said to be covered by the column, and the "primary" and "secondary radials."

Through the kindness of the late Dr. James Knapp of Louisville we have had an opportunity to examine several well preserved calices of the above species, and can state positively that it has but two series of plates. It seems that Shumard took the proximal joint of the column, which is generally attached, for basal plates, and the edges of the basal disk proper for "primary," the true radials for "secondary" radials.

Of *Catillocrinus Wachsmuthi* no descriptions were given of the plates in the calyx, but the arm structure of the genus was here for the first time described. Meek and Worthen, who had not seen Shumard's description of *Catillocrinus*, and being unacquainted with the arrangement of plates, referred their species at first to *Symbathocrinus*, not, however, to the typical form, but to a new subgenus, for which they proposed the name *Nematocrinus*. On a republication of the species, in vol. iii, of the Geological Report of Illinois, the above name was abandoned, and the species placed under *Catillocrinus.*

In *Catillocrinus Bradleyi*, Meek and Worthen undertook to describe also the plates of the calyx, but without applying to them their proper terms. They simply designated them as plates of a first and of a second series, except a few plates in the second series which they introduced as "anals (?)." Of the five plates in this series, three are easily recognized as radials, but also the two others, although much smaller and very irregular in form, are radials, as both are arm-bearing.

The one toward the right supports at one end an arm, at the other an elongate narrow anal plate, which abuts against the sides of the proximal arm joints, and has nearly their form, being only somewhat larger. Bigsby (Thesaurus Devonico-Carboniferus, p. 224) places *Catillocrinus* as a synonym of *Calceocrinus.*

We propose the following:—

Revised Generic Diagnosis.—General form, when the arms are folded, elongate-cylindrical. Calyx in form of a shallow basin or cup, concave at the bottom, uniformly truncate at the upper margin. It is composed of two series of plates; the upper one supporting the arms, which are very numerous. Test exceedingly thin along the basals, thickening rapidly upwards.

The basal disk is apparently undivided; the greater part hidden by the column. It is irregularly pentagonal, three of its sides being nearly equal, the other two, which are adjoining, equal to one-half the larger ones. The side opposite the two smaller sides extends considerably beyond the column, while at the other side the basal disk is either altogether invisible, or reduced to a very narrow band. This want of regularity has been observed in all specimens, and seems to be characteristic of the genus.

Radials five, very irregular in form, those of the antero-lateral rays much larger than the rest. The two larger plates, whose upper margins constitute fully three-fourths of the periphery at the top of the radials, occupy together less than one-half of the circumference of the basal cup. This disproportion is caused by the peculiar form of the other radials, which, notwithstanding the great spreading of the calyx, diminish in width upwards. The anterior radial is much smaller, heart-shaped, with strongly convex lateral edges, which converge almost to a point at the top of the calyx. The basi-radial suture is somewhat concave, and fully as wide as that of the larger plates. The two postero-lateral radials together are very little larger than the anterior one; that toward the right is smaller, very narrow, wider at the bottom than at the top, and triangular when the sides are straight; but when these are curved, which is more frequently the case, it is somewhat lunate. The other radial is quadrangular, fully twice as high as wide, and of equal width throughout.

The articular surface of the radials is provided with conspicuous grooves and intervening ridges, the former with a depression near the outer margin of the plate. The grooves along the surface take a tortuous or undulating course, and near their inner end turn rather abruptly toward the anterior radial. The latter plate has generally but one groove, which is deeper than any of the others and perfectly straight, but when it has two grooves, as is exceptionally the case in *Catillocrinus Tennesseæ*, these unite before entering the inner cavity. The two larger radials contain numerous grooves—the number varying with the species—that toward the right, as a rule, has more than the one on the left. The former radial has been observed to have in *C. Tennesseæ* 27 to 31 grooves, in *C. Wachsmuthi* 16 to 20; the plate toward the right in the former species has from 21 to 23, the opposite one 15 grooves. The two small irregular radials have, so far as observed, only one groove each.

In perfect specimens, the grooves are lined by two rows of short, transverse pieces, which partly cover the groove, but leave underneath a good-sized passage. The plates rest upon the ridges, where they abut against their fellows from adjoining grooves. With the exception of the ridges and grooves, the truncated upper side of the radials forms a uniform plane, interrupted only by a small elevation along the left side of the quadrangular radial. This elevation is occupied by a small, elongate anal plate, which abuts against the two proximal joints of adjoining arms. The plate is placed on a level with the arm joints, has a like width and, therefore, is easily mistaken for an arm plate.

The anal plate supports a very stout appendage, composed of a single row of exceedingly large and heavy plates, longitudinally arranged, which, instead of forming into a tube as in the case of other Fistulata, are transversely curved like arm joints, leaving a rather shallow, semicircular furrow on the inner side. These plates are along their back extremely heavy, as thick as the radials at their upper margins, but they thin out toward their ends, and approaching the furrow become extremely delicate. The proportions of the plates are well shown by our figure of *Catillocrinus Wachsmuthi* (Pl. 5, fig. 16), in which five of these plates occupy an inch, while in the same space there are seventeen arm joints. It must be further mentioned that up to that point the plates suffered no diminution in height nor in width, nor is there any decrease in the thickness of the wall, which in *Catillocrinus Wachsmuthi*, at the top of the fifth joint, is nearly two-thirds of the whole width of the appendage. The cross section is semilunular except at the base. The stoutness of the plates on the one side, and the grooved structure on the other, are perhaps due to the great thickness of the radial plates upon which the tube rests; it had to be so necessarily in order to effect a communication with the inner cavity of the calyx. The groove was probably covered during life by perisomic plates. No traces either of a vault or a disk have been observed.

The arms rise directly from the truncated summits of the radials, without the intervention of axillary plates. There is an arm to every groove, and, hence, some of the radials, contrary to the rule in other Crinoids, support a large number of arms from the same level. The arms are simple, slender, comparatively long, scarcely rounded outwardly, of almost uniform size, and when closed they appear as if united into a solid wall. The arm joints are quadrangular, much longer and somewhat deeper than wide, with parallel sutures. Arm furrows deep, triangular.

The column is circular, composed of thin joints, the upper part is very stout but tapers rapidly downward.

Geological Position, etc.—The genus is apparently restricted to the Upper Burlington and Keokuk divisions of the Subcarboniferous of America.

The following species have been described :—

1868. **Catillocrinus Bradleyi**, Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 342; also 1868, Geol. Rep. Illinois, vol. v, p. 504, Pl. 14, figs. 10 *a*, *b*.—Keokuk limest. Crawfordsville, Ind.

1850. **Catillocrinus Tennesseæ** Troost (Type of the genus). List Crin. Tenn., Proceed. Amer. Assoc., p. 60.—Shumard, 1868, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.—Keokuk limest., Button-mould Knob, near Louisville, Ky.

1866. **Catillocrinus Wachsmuthi**, Meek and Worthen. (**Symbathocrinus [Nematocrinus] Wachsmuthi.**) Proceed. Acad. Nat. Sci. Phila., p. 251. **Catillocrinus Wachsmuthi**, 1868, Geol. Rep. Ill., iii, p. 465, Pl. 18, fig. 5.—Upper Burlington limest. Burlington, Iowa.

MYCOCRINUS Schultze.

1866. Schultze, Monogr. Echin, Eifl. Kalk., p. 222.
1879. Zittel, Handb. d. Palæontologie, vol. i, p. 380.

Schultze supposed that *Mycocrinus* had no arms, but his own figures and description indicate the contrary. The radials are provided close to the periphery, and in front of the ambulacral grooves, with well developed articular facets, pierced by transverse slits.

Mycocrinus resembles the last described genus very closely, but differs in the bipartite basal disk, the greater symmetry and regularity in the arrangement of the radials, and in the general form. We offer the following :—

Revised Generic Diagnosis.—Calyx in form of a mushroom, constructed of two series of plates, the upper series forming the thallus, the lower the stalk. The plates are massive, of very irregular form, and without ornamentation.

Basals two, large, unequal; one of them twice as large as the other. They are very heavy and form a distinct, subglobose, knob-like body, slightly truncate below for the reception of the column. Its upper side rises to form a low five-sided pyramid, near the outer margins of which there are twelve narrow slits parallel to the edges. Two of the sides have three slits each, the three others two each.

Radials five, resting with their inner edges upon the angular margin of the basal disk, each plate facing one of the five sides of the pyramid. They spread broadly outward from the edge of the basals, and extend far beyond their outer margins. Two of the radials are of equal width, much larger than the rest. These two are separated from one another at one side by two equal, much smaller plates, at the other by a single plate somewhat larger than the two others. The single plate is more than one-half narrower above than below, owing to an angular extension at the lower half of its two lateral faces, which fit closely into the adjoining excavated side of the large radials. Similar processes arise from the sides of the two smaller plates, but here only along the suture toward the larger one, the opposite suture being perfectly straight. By means of the lateral extensions, the large radials, which at their basi-radial suture have nearly the same width as the smaller ones, attain at their upper face three times the width of the other plates.

The articular surface of the radials is truncated, unusually thick, and closely resembles that of *Catillocrinus. Mycocrinus boletus* must have had fifteen arms, for there are fifteen rather shallow ambulacral grooves, which pass from near the periphery of the calyx to the radial centre. There are six upon each of the two large radials, and one upon each of the two smaller ones. The six grooves upon the two larger radials unite into one, and hence there are but five main trunks entering the inner cavity. The median part of every groove has a deep linear furrow, which takes a somewhat downward course, and penetrates the walls of the radials. Close to the periphery, outside of each groove, there is a well-marked slit-like axial canal, making fifteen in all, which pierce the radials throughout their full length, and enter the upper margins of the basals. These canals or tunneled passages are evidently axial canals, which entered through the twelve slit-like openings at the inner floor of the basals the chambered organ, and as such communicated with the arms.

The body cavity is very small, its width not equaling the thickness of the radials; its depth being less even than its width. Form of the arms, construction of summit and anus unknown.

The column seems to have been circular, with a small, round central canal. The only species is :—

1866. **Mycocrinus boletus** Schultze, Monogr. Echin. Eifl. Kalk., p. 222, Pl. 7, fig. 4. —Stringocephalenkalk, Devonian.—Nollenbach (Eifel), Germany.

FAMILY XXVI.—CALCEOCRINIDÆ Meek and W.

1878. Meek and Worthen, Geol. Rep. Illinois, v, p. 443.
1882. De Loriol, Paleont. Française, vi (Crinoides), p. 51.
Syn. *Chirocrinidæ*, Angelin, 1878, Icon. Crin. Suec., p. 22.
Syn. *Cheirocrinidæ*, Zittel, 1879, Handb. d. Palæont., i, p. 357.

The only known genus of this family has been variously referred to *Cheirocrinus* and *Calceocrinus*. As early as 1851, Hall, in the Geological Report of New York, vol. ii, p. 352, gave notice of a peculiar Crinoid from the Niagara group, of which he had obtained what appeared to be a bipartite base or pelvis showing a columnar attachment, for which he proposed the name *Calceocrinus.* In 1860, in the 13th Regents Report of the New York State Cabinet of Nat. History, the same author described under *Cheirocrinus* six new species of American Crinoids having a base similar to *Calceocrinus*, and which evidently belonged to that or a very closely allied genus. According to Salter (Murchison's Siluria of 1859), the name *Cheirocrinus* had been used by Austin in MS. for a similar form from the Wenlock limestone, but Eichwald had already in 1856 preoccupied the name for a certain type of Cystidea. Shumard was the first writer to direct attention to the probable identity of *Calceocrinus* with Hall's *Cheirocrinus*, and in his Catalogue of the Palæozoic Fossils of North America he added the name *Calceocrinus* in parenthesis to all described species of *Cheirocrinus.* In this he was followed in 1869 by Meek and Worthen, and in 1879, Hall himself adopted *Calceocrinus*, while both Angelin and Zittel have retained *Cheirocrinus.* It seems to us the latter name, according to established rules, cannot be upheld for Hall's type, because it was preoccupied by Eichwald for a Cystid, and even if it be true, as asserted by F. Schmidt (Acad. Imp. Sci. St. Petersburg, Ser. ii, vol. xi, No. 11), that Eichwald's *Cheirocrinus* is identical with *Glyptocystites*, which has priority, this would not alter the case. The same view was evidently taken by Meek and Worthen, who proposed, in case doubt should arise as to its identity with Hall's type of *Calceocrinus*, to change the name *Cheirocrinus* into *Eucheirocrinus.*

We would accept the latter name, had not Hall himself, who had the best opportunity to compare the type specimens, given preference to *Calceocrinus.* Bigsby, in the Thesaurus Devonico-Carboniferus, erroneously placed the genus *Catillocrinus* as a synonym under *Calceocrinus.*

Calceocrinus was made by Meek and Worthen, in 1873, the type of a distinct family, for which they introduced the name "*Calceocrinidæ.*" This was adopted by De Loriol, but Angelin and Zittel in their classification apply the name "*Cheirocrinidæ.*"

Calceocrinus differs in external appearances so essentially from all other Crinoids, that Hall introduced for its description a special terminology, which was adopted by all succeeding writers.

In this special names were given to parts of the calyx, which, as we will presently show, are represented in other genera, and hence should be designated by the same name, the more since some of his appellations conflict seriously with terms long ago established.

Hall divided the calyx into two parts. The one, which he called the "dorsal side," comprises the anterior side and not, as should be expected from the name, the aboral part; the other, which he designated as the "ventral side," by which are usually understood the oral or summit portions, represents the posterior side. According to Hall, the "dorsal side" consists of three—perhaps sometimes five—"basals," of the "upper and lower dorsal plate" *or the first and second anterior radials*, and of the right and left "dorso-lateral plate" or *lateral radials.* He further discriminates between "plates of the dorsal arm," *the brachials of the anterior ray*, and those of the "dorso-lateral arms," or *arm plates of the lateral rays.* The "ventral" side is described as being composed of the "ventral arching plate"—which actually consists of two pieces, and which either are *anal plates*, or non-arm-bearing radials—and succeeding these of a row of plates, longitudinally arranged, which were designated as "plates of the ventral side," but which are *plates of an anal tube.* There are besides summit or vault pieces which, however, were not described by Hall.

The most remarkable feature of this genus is represented by the basals, which are located on the posterior side of the calyx. They connect with the plates of the anterior side, which is truncated, toward the basals, not by suture as in the case of other Crinoids but by muscles and ligament, thus producing between basals and radials a marked articulation. There is a widely gaping suture along the articular line, which, as Meek and Worthen suggested, permitted the basals to be opened out on a line with the radials and other parts of the calyx. That the calyx was capable of bending at this point is well shown by a unique specimen of *Calceocrinus tunicatus* Hall, in the possession of Mr. James Love of Burlington, in which the main body stands out from the column at an angle of sixty degrees; while in most of the specimens which we have examined the crinoid hangs downward, almost parallel with the column. No specimen, however, shows the calyx in an erect position.

There are in this genus but three rays, which vary considerably in form and size. The two lateral rays are composed of a large radial, which is followed by two very small brachials. The anterior ray has two radials, which combined are smaller than the single lateral ones. The two are generally separated by the lateral radials which join between them, placing one of the plates at the upper, the other at the lower end of the calyx. This peculiar structure has evidently prevented all former writers from recognizing those plates as radials. That they are radials, and were gradually separated in the course of palæontological times, is proved by Hall's Silurian species *Calceocrinus chrysalis* and *Calceocrinus inæqualis* Billings,[1] by *C. radiculus* Ringueberg and *C. Barrandii* Walcott, in all of which the plates are narrowly elongate, and united by a short suture. In *Calceocrinus gothlandicus* of Upper Silurian age, they are separated, but the first radial extends almost to the second. In *Calceocrinus clarus* and *Calceocrinus Barrisi* from the Devonian, the distance that separates them is somewhat greater; while in all Subcarboniferous species the two plates stand widely apart.

Calceocrinus agrees with *Catillocrinus* in the arrangement and form of its plates. In both of them the second ring consists of five extremely irregular pieces, but, while in the latter all five are arm-bearing, those of *Calceocrinus* are arm-bearing only in the three anterior rays. The two posterior ones are small and support a large tube. The corresponding plates in *Catillocrinus* support upon one end of their upper side an arm, upon the other a similar tube as *Calceocrinus*, and in both genera the two anterolateral rays are far stronger developed than any of the others. The two forms resemble each other more closely than might be expected from Crinoids that differ so widely in their general aspect, as shown by changing *Catillocrinus* from its natural position into that of a *Calceocrinus.* This may be done theoretically by pressing the calyx sideways in such a manner that the basals are pushed over to one side, and the three arm-bearing radials to the opposite side. The lateral ones, however, owing to their large size naturally extend to the basal side, where they join the small postero-lateral radials, which, as stated, hold a similar position as the anal plates in *Calceocrinus*, resting like them against the basals and supporting a similar anal tube. By thus changing the respective parts into a relative position, the affinities which exist between the two genera can be better appreciated. The form of the calyx, however, the articulation between the basals and radials, and the sloping position of the lateral rays is so unique, and strikingly different from *Catillocrinus* and other genera, that *Calceocrinus* must be referred to a distinct family.

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[1] It was Mr. Walter R. Billings, of Ottawa, who already in 1883 directed our attention to *Heterocrinus inæqualis* as being a *Calceocrinus*, and he informed us also that in this species the two anterior radials were joined by sutures.

The slight variations, which naturally occur in the branching of the arms, were taken by Hall, and Meek and Worthen, for specific distinctions. We fear these differences are too trifling to be regarded as such, and we have felt obliged to refer some of their species to our list of synonyms.

Postscriptum.—While our descriptions upon the Calceocrinidæ were in press, we received a paper from Mr. E. O. Ulrich (extracted from the 14th Ann. Rep. Geol. Surv. Minn., p. 104): Remarks upon the names Cheirocrinus and Calceocrinus, with descriptions of three new generic terms and one new species. The author subdivides the species heretofore known under *Calceocrinus* into three genera : *Cremacrinus*, *Deltacrinus* and *Halysiocrinus*, and applies to them the family name "Cremacrinidæ." There is, in our opinion, no valid reason for discontinuing the names *Calceocrinus* and *Calceocrinidæ.* The genus *Calceocrinus* was properly defined by Hall and others, and several species have been referred to it by them. Moreover, Meek and Worthen's name *Eucheirocrinus* would have priority, and also Calceocrinidæ, as both were proposed in 1873.

Under *Cremacrinus* Ulrich placed the species in which the two anterior radials (the two central plates of his) are connected vertically; under *Deltacrinus* those in which said plates are separated by the two lateral radials (his two large dorso-lateral pieces). This difference, we admit, exists between the Lower Silurian and Subcarboniferous species, but in the Upper Silur and Devonian the two forms pass gradually into one another, so as to make a generic separation impracticable. Ulrich's statement on p. 110, that *Cremacrinus* has " three primary radials," *Deltacrinus* " five," *Halysiocrinus* " eleven," is based altogether upon incorrect observation. All these species have but three arm-bearing radials—one of them compound—and the plates which Ulrich regarded as " eleven primary radials," are axillary brachials of ascending orders.—(May, 1886).

CALCEOCRINUS Hall (Revised by W. and Sp.).

1851. Hall, Geol. Rep. N. York, vol. ii, p. 352, Pl. 85, figs. 5, 6.
1866. Shumard, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.
1869. Meek and Worthen, Proc. Acad. Nat. Sci. Phila., p. 73.
1873. Meek and Worthen, Geol. Rep. Illinois, vol. v, pp. 442 and 502.
1877. S. A. Miller, Cat. Amer. Palæoz. Fossils, p. 72.
1879. Hall, 28th Rep. N. York St. Cab. Nat. Hist. (Ed. ii), p. 146.
1882. De Loriol, Palæont. Francaise, Tome xi (Crinoides), p. 51.
1882. Ringueberg, Journ. Cincin. Soc. Nat. Hist., p. 120.

Syn. *Cheirocrinus* Hall (not Eichwald, 1856); Hall, 1860, 13th Rep. N. York St. Cab. Nat. Hist., p. 122 ; Salter, 1859, Murch. Siluria (Ed. 3), p. 535 (Catalogue name); Hall, 1862, 15th Rep. N. Y. St. Cab. Nat. Hist., p. 166 ; Zittel, 1879, Handb. d. Palæont., i, p. 358.
Syn. *Chirocrinus*, Angelin, 1878, Icon. Crin. Suec., p. 22.
Syn. *Pendulocrinus*, Austin MS. (Salter, Siluria, p. 535).
Syn. *Eucheirocrinus*, Meek and Worthen, Geol. Rep. Ill., v, p. 443.

In general form the specimens resemble a wilted flower, owing to the position of the calyx, which hangs downward along the column. The calyx is laterally compressed, especially at the juncture of basals and radials, where it is almost linear; while a transverse section across the median part of the radials and through the centre of the basal disk is decidedly triangular. The anterior side forms a flat body, broadly truncate at the lower end, constricted in the middle, and composed exclusively of the radial plates. The basals, which are placed upon the posterior side, are separated from the radials of the opposite side by a widely gaping articular line, occupying the lower end of the calyx. Along this line, probably, the upper part of the Crinoid could be bent upwards and be brought in an erect position. The posterior side is composed, in addition to the basals, of two non-arm-bearing plates, which face laterally the incurving sides of the radials, and support upon their upper side an extremely large ventral tube.

The basals jointly form a kind of semicircular disk, of which the straight line faces the truncated lower side of the anterior radial, and the curved part rests against the infolding lateral margins of the lateral radials, and against the two non-arm-bearing plates. The basal disk, which is slightly convex, is composed of three pieces, two of which are equal, the other large and of a very different shape. The two former taken together are lunate, and enclose within their arched sides the other plate, which lies transversely, and occupies almost the entire width of the truncated side of the basal disk. The articular facet for the attachment of the column has a lateral position, and is placed within the centre of the two equal pieces, without touching at any point the third plate. It is large, somewhat excavated, and divided vertically by the suture line.

The radials consist of four plates of very irregular arrangement. The two larger ones, those of the lateral rays, occupy more than two-thirds of the anterior side of the calyx, and support two small transverse brachials, of which the upper one is axillary. Two much smaller and very irregular plates, which are generally separated by the large lateral pieces, form the radial of the anterior ray. The large lateral radials are bent abruptly along their outer sides, so as to occupy considerable space upon the posterior side of the calyx. They are hexagonal—rarely pentagonal—angular at their upper and lower ends; one of the lower sloping sides abuts against the first anterior radial, the other against the basal disk. The sloping upper face connects at one side with the second anterior radial, the opposite side supports the first brachial plate. Of the lateral faces one meets the corresponding side of the opposite radial, the other an anal plate. In the anterior ray, the first radial is linear, but more frequently triangular, two of its sides resting within a re-entering angle formed by the lateral radials. The lower edge is generally wider, and constitutes the bottom part of the anterior face of the calyx, being on a level with the truncated edge of the basals, and united with them by muscular articulation. The articulating surface, near the outer margin of the component plates, is provided with a deep fossa, evidently for the lodgment of elastic ligament. A similar but narrower fossa is placed close to the inner margin of the plates, separated from the former by a narrow transverse ridge. The middle part of this ridge extends somewhat into the large fossa, and forms a kind of triangular projection which contains a small axial canal. The second anterior radial has nearly the same form as the first, but its position is reversed, the truncate side being directed upwards, the angle downwards, resting between the sloping upper sides of the adjoining basals. In *Calceocrinus chrysalis*, in which the first anterior radial joins the second, both plates are exceptionally quadrangular, and, therefore, the first lateral radials pentagonal instead of hexagonal. The plates above are free. There are two brachials in each lateral ray, a single one in the anterior one. The articular line between the lateral radials and brachials is widely gaping, the union between the two succeeding plates apparently by syzygy. They are closely fitted together in the specimens, and a suture is rarely discernible. The lower one is short and quadrangular, the upper one axillary. The brachial of the anterior ray is generally twice as wide as high, and truncate at its upper side.

It has been stated that in the lateral rays the first brachials are placed obliquely against the radials, in consequence of which these two rays lean over toward the posterior side. By this peculiar structure, the outer sloping faces of the bifurcating brachials are brought into a vertical, the inner ones into a horizontal position. The vertical side supports laterally another axillary, the horizontal side vertically a free arm. The former is followed again by an axillary on one side, and an arm on the other, and so on in the same manner to the last bifurcation, the axillary plates all arranged in a nearly horizontal line, the free arms having an upright direction. In species with but few bifurcations the position of the brachials is more erect.

The arms are composed of single joints, which are generally as long as wide; rounded exteriorly and provided with a deep triangular groove at the ventral side; they are comparatively long, rather stout at the base, but taper gradually upwards. The lateral arms, after their first bifurcation, do not branch again, but give off from every third or fourth joint a large arm-like pinnule, which extends to the end of the arm. The lower pinnule is less than half the size of the arm at the place of attachment; the one or two succeeding ones have nearly the same size as the arms at the place of their origin. The pinnule-bearing joints appear to be somewhat stouter owing to a thick callosity at their upper end, and their line of articulation is directed obliquely. The intermediate joints have parallel sides, which show neither fossæ nor radiations, and probably were united simply by suture. The anterior ray has but a single arm, which is given off in an upright direction. It is stouter than the lateral arms, and remains frequently simple throughout, but when it branches occasionally, the division takes place near the distal end.

Anal plates two, resting against the basals and the incurved wings of the lateral radials. Their upper side supports a row of very large and heavy quadrangular plates, which are longitudinally arranged and form the exterior side of an enormous anal tube, extending to the tips of the arms and perhaps beyond their limits, with scarcely any diminution in size. Like in *Catillocrinus*, only the posterior side of the tube is heavily plated, the anterior side being composed of very small and delicate plates.

The column is comparatively large, near the calyx composed alternately of shorter and longer segments, which soon turn altogether into long joints. Hall gives the column as very short; it was, however, of considerable length in some cases, as we have followed it up to a foot or more without reaching the root.

Geological Position, etc.—*Calceocrinus* makes its appearance in the Lower Silurian, but only in America. It struggled through the Devonian, and reached its greatest distribution in the earlier periods of the Subcarboniferous, but without flourishing abundantly. Throughout this long period of time, the species change but little, less than those of any other genus, and it is exceedingly difficult to point out specific differences, which in most of them are so slight that they hardly deserve the name. In Europe it has been found only in the Upper Silurian.

We recognize only the following species:—

1883. **Calceocrinus Barrandii** Walcott, 35th Rep. N. Y. St. Mus. Nat. Hist. (Author's Edit., p. 6), Pl. 17, figs. 1, 2.—Upper part of Trenton limest. Trenton Falls, New York.

1865. **C. Barrisi** Worthen, Geol. Rep. Illinois, iv, p. 510, with woodcut.—Hamilton group. Near Davenport, Iowa.

1869. **C. Bradleyi** Meek and Worthen, Proceed. Acad. Nat. Sci. Phila., p. 73; also 1873, Geol. Rep. Ill., vol. v, p. 502, Pl. 14, fig 9.—Keokuk limestone. Crawfordsville, Indiana.

1860. **C. chrysalis** Hall (**Cheirocrinus chrysalis**). Type of the genus.—13th Rep. New York State Cab. Nat. Hist., p. 123, with diagrams. Shumard, 1866, **Calceocrinus chrysalis**, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.—Niagara group. State of New York.

1862. **C. clarus** Hall (**Cheirocrinus clarus**), 15th Rep. New York State Cab. Nat. Hist., p. 116, Pl. 1, fig. 17.—Shumard, 1866, **Calceocrinus clarus**, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.—Zittel, 1879, Handb. der Palæont., i, p. 358, figs. 2, 4, 5 *a*.—Hamilton group. Ontario Co., N. Y.

1878. **C. gotlandicus** Angelin (**Chirocrinus gotlandicus**), Iconogr. Crin. Suec., p. 22, Pl. 16, figs. 6–14.—Zittel, 1879, Handb. der Palæont., i, p. 358, figs. 245, *b*, *c*, *d*.—Upper Silurian. Gothland, Sweden.

1859. **C. inaequalis** Billings (**Heterocrinus inaequalis**), Geol. Surv. Canada, Decade iv, p. 51, Pl. 4, fig. 7 *a*; Wachs. and Spr. Revision i, p. 70.—Trenton limestone, Ottawa.

1866. **C. perplexus** Shumard, Trans. Nat. Sci. St. Louis, vol. ii, p. 358.—Keokuk limest. Button-mould-Knob, Ky.

1882. **C. radiculus** Ringueberg Journ. Cincin. Soc. Nat. Hist., vol. v, p. 120, Pl. 5, fig. 4.—Niagara group. Lockport, N. Y.

1862. **C. stigmatus** Hall (**Cheirocrinus stigmatus**), Trans. Alb. Inst., vol. iv, p. 225 (Abstr. p. 31).—Shumard, 1866, **Calceocrinus stigmatus**, Trans. Acad. Sci. St. Louis, vol. ii, p. 358; also Hall, 1879, 28th Rep. N. York St. Cab. Nat. Hist., p. 147, Pl. 19, figs. 9–11; also 11th Ann. Rep. St. Indiana by Collett, 1881, p. 281, Pl. 19, figs. 9–11.—Niagara group. Waldron, Indiana.

1860. **C. tunicatus** Hall (**Cheirocrinus tunicatus**), 13th Rep. N. York St. Cab. Nat, Hist., p. 124, with diagram.—Shumard, 1866, Trans. Acad. Sci. St. Louis. vol. ii, p. 359.—Keokuk limestone. Keokuk, Iowa, Niota and Warsaw, Ill.

1860. **C. ventricosus Hall** (**Cheirocrinus ventricosus**), 13th Rep. N. Y. St. Cab. Nat. Hist., p. 123.—Shumard, 1866, Trans. Acad. Sci. St. Louis, vol. ii, p. 359.—Burlington limest. Burlington, Iowa.

Syn. **Cheirocr. dactylus** Hall, 1860, 13th Rep. N. York St. Cab. Nat. Hist., p. 123.—Burlington limestone.

Syn. **Cheirocr. nodosus** Hall, 1860, Ibid.—Keokuk limestone.

Syn. **Cheirocr. Wachsmuthi** Meek and Worthen, 1869, Proc. Acad. Nat. Sci. Phila.—Burlington limestone.

Syn. **Calceocr. dactylus** Shumard, 1866, Trans. Acad. Sci. St. Louis, vol. ii, p. 358.

Syn. **Calceocr. Wachsmuthi**, Ibid.

APPENDIX.

(*January*, 1886).

STEPHANOCRINIDÆ W. and Spr.

Through the kindness of Prof. R. P. Whitfield, to whom we are under lasting obligations, we had lately an opportunity to examine from the collection of the American Museum of Natural History of New York City, some valuable and unique specimens of the genus *Stephanocrinus*. Among these were 25 specimens of *Stephanocrinus angulatus* Conrad, two of them showing the brachial appendages—the so-called pinnules—and 18 specimens of *Stephanocrinus gemmiformis* Hall.

Stephanocrinus is one of those genera which prove to us how inappropriate it is to make Crinoids, Cystids and Blastoids distinct classes. The genus has been regarded by F. Roemer, Johannes Müller and Pictét to be a Cystid, by Messrs. Etheridge and Carpenter and S. A. Miller a Blastoid. Dujardin and Hupé —and apparently (?) Hall—refer it to the Crinoids; while Prof. Zittel was in doubt whether he should place it with the Blastoids or not. That it has certain affinities with either one of the three groups cannot be denied. It agrees by its oral and anal pyramid with certain forms of the Cystids, while in its general habitus and in the position of the ambulacra it agrees with the Blastoids; and yet it is, as we shall prove, unquestionably a Palæocrinoid.

It seems Roemer[1] had discovered sockets for the reception of brachial appendages, and probably these sockets and the valvular covering of mouth and anus induced him to place the genus with the Cystidea. Johannes Müller, who also regarded it a Cystid, makes the remark: "Nierenförmige Warzen am Ende der Strahlen des sternförmigen Feldes deuten auf die Gegenwart von Armen hin." Hall, in vol. ii, p. 351, of the New York Report, does not describe the appendages which he had discovered as Blastoid pinnules, but speaks of tentacula attached to the margin along a slight groove in the base of the depressions between the angular processes which ornament the summit of the body. These tentacula or *fingers consist of ten branches*, each composed of a double series of plates above, *but uniting below a series of coalescing plates which have a different arrangement.* It seems to us this description does not apply to ambulacral appendages, nor do we think that Hall took the genus to be a Blastoid. On p. 212 of the New York Report he called it a Crinoid, and in 1879 he placed it aside of well-known Palæocrinoidea. Pictét describes the base as composed of "five subradials," and "five basals," and the mouth as surrounded by "ten tentacles." Dujardin and Hupé place it among the Haplocrinidæ, between *Haplocrinus* and *Coccocrinus*, and also these writers describe within the radial groove a reniform impression for the reception of an arm, but thought to observe "lames paralleles" along the grooves. They regard, like Roemer, the central pyramid, the mouth, and the lateral aperture an ovarian opening.

Considering that Hall, Roemer, Müller, and Dujardin and Hupé, all describe at the outer end of the ambulacral groove a reniform scar for the attachment of an appendage, it is somewhat surprising that Etheridge and Carpenter place the genus among the Blastoids. They undertake to explain this by Hall's discovery of "ambulacral appendages . . . . like those of other Blastoids," and give it as their opinion that the reniform scar of Roemer "is nothing more than an infolded radial lip." We stated already that we thought Hall never regarded *Stephanocrinus* a Blastoid, and he certainly did not describe ambulacral appendages, but branching fingers, no matter what name he gave to the parts. We are confident that the depression at the end of the ambulacral groove really does exist, and that it is occupied by a second radial.

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[1] We do not possess Roemer's description of *Stephanocrinus* which appeared in Wiegmann's Archiv for 1850, and know it only from the quotations of subsequent writers.

Stephanocrinus not only has two radials to each ray, but branching biserial arms, given off in a somewhat similar manner as the arms in the Platycrinidæ. The second radials are reniform, small, bifurcating, and rest within a semi-ovoid or horseshoe-shaped depression near the outer end of the ambulacral groove. They are succeeded by two or more axillaries of a higher order, which in the usual way give origin to ten arms to each ray. That these appendages, although they are equally thin and short, are not pinnules, is proved by the fact that all are supported by a radial plate, instead of being distributed separately along the sides of an ambulacrum. It is further shown by one of the New York specimens, in which in one of the rays the appendages became disconnected, and were deposited *en masse* at some little distance from the radials, without the least disturbance in their arrangement, a case which could not have happened if they were ambulacral pinnules.

The ambulacra of *Stephanocrinus* are constructed very differently from those of the Blastoids; they possess no side-pieces, no transverse furrows, no hydrospire pores, and no sockets for the reception of pinnules; they simply are covered by two rows of Saumplättchen, which enclose a tubular canal containing the food groove. The Saumplättchen or covering pieces of the same row are so closely anchylosed to one another, longitudinally, that it appears even under an ordinary magnifier, and in the most perfect specimens, as if there were but two elongate plates, one at each side. As such they were represented by Hall in his diagramatic figure, New York Geol. Rep., vol. ii, Pl. 48, fig. 1 *l*, in which the reniform plates at the outer end of the elongate pieces represent the second radials. The figure shows excellently the plates of the ventral side as they generally appear in the specimens; there is omitted, however, a suture along the so-called coronal processes, which Hall, as well as Roemer, thought he observed, but which were not accurately defined until 1883, by Etheridge and Carpenter (Ann. and Mag. Nat Hist., April, p. 239). They found the processes " divided into an outer part formed by the contiguous limbs of two adjacent radials, and an inner portion or deltoid,[1] and that the calyx consists of three rows of plates—the basals, radials and deltoids. The canals which contain the food grooves are in their usual preservation, more or less compressed, and in consequence thereof the two series of covering pieces became separated longitudinally, and appear in the specimens as if forming a deep groove upon the surface following the median line. Little of this groove, however, is seen in plump specimens.

Etheridge and Carpenter, and also Zittel, regard the two rows of anchylosed covering plates as constituting a single piece, and this, they think, represents the lancet plate of the Blastoids. Upon this point they make on p. 240 of their paper the following statement: "The paired linear plates in the ambulacra we believe to be single, and to represent the lancet plates of other Blastoids. They seem to be usually much eroded and to have a strongly marked median groove, which has been taken for a suture. Even when these plates are preserved the side plates of the ambulacra are generally missing; but since Hall has discovered specimens of *S. angulatus* still attaining ambulacral appendages like those of other Blastoids, we see no reason to doubt the existence of side plates and outer side plates. In fact, the former have been described in *S. pulchellus* by Miller and Dyer." We doubt if Etheridge and Carpenter ever saw a *Stephanocrinus* with either side pieces or outer side pieces, or ever will see one, and if Miller and Dyer found such plates in their *St. pulchellus*, we assert that their species is not a *Stephanocrinus*. Aside from the fact that the " so-called lancet pieces " are compound structures, we think it utterly impossible from the position which these plates occupy toward the oral plates, that they could represent lancet pieces, as in that case the food grooves would have to run out into the air in place of entering the interior.

In both of the New York species, the oral plates are on the same level with the covering pieces; they meet with each other so as to leave externally, when both plates are in position, no opening or passage. The only communication with the inner cavity, in connection with the ambulacra, is beneath the covering plates through the canals or tunnels which we have described. These passages, which are closed at the bottom by the deflected lateral edges of two adjoining interradials, as in the case of *Cyathocrinus*, grow deeper and narrower on approaching the oral plates; while toward the arms they widen and divide, transmitting a branch to each main division of the rays. All this goes to prove that the passages are tubular canals, such as we find in the Palæocrinoidea, and that the apparent resemblance between the ambulacra of *Stephanocrinus* and those of the Blastoids, to a large extent, is superficial.

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[1] We have substituted here *deltoids* for "*orals*," the latter term being used by Etheridge and Carpenter in their paper. When they wrote this they still regarded the deltoids as representing the orals, a mistake which Dr. P. H. Carpenter explained and corrected in his Challenger Report, p. 162.

The oral pyramid, which is rather symmetrical in outline, occupies the very centre of the ventral surface. It is composed of five pieces of nearly equal size, which meet in the centre, and are so closely connected by suture that the lines of union are rarely seen in the specimens. A less close union seems to have existed toward the interradials, for the oral plates are but seldom preserved, when we find in their place a nearly circular opening.

The radials extend to the full height of the coronal processes, and resemble in their form closely the forked plates of certain Blastoids; while in Hall's figure (N. York Rep., vol. ii, Pl. 48, figs. 1*h* and 2*f*) they appear like the radials of a *Platycrinus*. Hall evidently mistook the cracks which so frequently are found at the base of the interradial processes, for sutures, and supposed the united limbs of two contiguous radials, formed a deltoid-shaped interradial plate.

The most interesting feature of *Stephanocrinus* unquestionably is the quinque-partite oral pyramid, which, we think, gives us valuable information regarding the undivided oral plate in other groups of the Palæocrinoidea. It was suggested by us on p. 55, that probably the central or oral plate of the Palæocrinoidea primitively consisted of five pieces, of which the suture lines gradually were obliterated by deposition of new material. In support of this theory we could only refer to the parallel cases of the basals and underbasals among which similar modifications took place not only palæontologically by anchylosis of one or more of the plates, but also in the growing Crinoid by deposition of limestone at the outer surface of the plates, as in the case of *Edriocrinus* and *Agassizocrinus*. We were unable at that time to point out a single Palæocrinoid in which the peristomial area was closed by five plates, and therefore regard the case of *Stephanocrinus* of the utmost importance, not only as confirming our suggestions, but as throwing light upon the orals of the Palæocrinoidea generally. Before, however, we discuss this question any further, it will be necessary to point out the relations of *Stephanocrinus* with other Crinoids.

Stephanocrinus, undoubtedly, is closely allied to *Allagecrinus*, *Haplocrinus* and *Pisocrinus*, and must be placed with them among the Larviformia, but, owing to marked differences in the form and arrangement of the arms, it cannot be arranged either with the Haplocrinidæ or Symbathocrinidæ, and it will be necessary to establish for it a separate family. Except in the arm structure, the affinities seem to be particularly close with *Pisocrinus*, which has similar interradial processes, formed likewise by the extended limbs of the radials; but as we know little or nothing of the oral plates and ambulacral structure in this genus, a critical comparison is difficult. It differs also from *Haplocrinus* in the position of the disk-ambulacra, which in the latter are subtegminal, in the other exposed to view. This, we explain by individual growth, and assert from palæontological evidence that *Stephanocrinus*, like *Cyathocrinus* and other Palæocrinoidea in its younger state passed through stages in which it closely resembled *Allagecrinus* and *Haplocrinus*. Admitting this, it will be interesting, and instructive, to transform theoretically the lower differentiated *Haplocrinus*, so as to conform with the conditions of the adult *Stephanocrinus*. To this end we open out the five ventral plates of *Haplocrinus*, so as to expose their ambulacral skeleton, and push the ambulacra and the oral plate, which latter occupies the central portions of this skeleton, in an outward direction, in such a manner that the covering pieces fill up the clefts between the interradial plates, and the oral plate the centre, increasing in size as the space gradually grows larger. Nothing further is necessary to complete the structure of *Stephanocrinus* but to extend the sides of the interradials laterally, so as to close the ambulacral groove from beneath. By these manipulations, in which, we think, we closely imitated the natural development as it took place among Palæocrinoids palæontologically, we placed the two genera in the same relative position, in hopes to arrive thereby at a satisfactory conclusion as to the morphological resemblance of the respective plates.

In *Stephanocrinus* interradials have been admitted, and the plates which do represent them correspond in our hypothetical Crinoid with the plates which we opened out to receive the ambulacra. The plates have relatively a similar position, both rest against the upper edges of two adjoining radials, and both support a small pyramid or disk, which in both cases not only occupies a strictly central position, but covers the peristomial area and closes the oral pole. Now, if this is true, what makes those plates interradials only in the one case and not also in the other, and why does the central disk which they enclose represent the oral pyramid in the one and something else in the other? That the central pyramid is quinque-partite in *Stephanocrinus*, coalesced in the other, is apparently the only structural difference between the two forms, and simply upon this ground the former has been regarded by Carpenter (Chall. Rep., pp. 269 to 271) an oral pyramid, and the central plate of *Haplocrinus* a so-called "orocentral," something totally unknown in Crinoid morphology and that of Echinoderms generally.

According to Carpenter the orals of *Haplocrinus* were represented by the five large ventral plates, although these, like the interradials of other Palæocrinoids, apparently cover the disk and tentacular vestibule, contrary to the case of the orals and summit plates generally which close only the peristomial area. If *Haplocrinus* did represent a permanent larval form of the Neocrinoidea instead of the Palæocrinoidea, Carpenter would be justified in regarding those five plates as orals, and could assert that the plates were in the growing animal, and in palæontological times carried inward by perisome, as he and Etheridge suggested to have been probably the case in the growing *Allagecrinus*, but we cannot find in the phylogeny of the older Crinoids the least evidence to justify that supposition. On the contrary, everything points at the conclusion that the orals, and other summit plates, had relatively the same proportions in the younger and lower forms, as in the adult and higher types; and we, therefore, regard the respective plates in *Haplocrinus* like those of *Stephanocrinus*, *Cyathocrinus* and the Blastoidea, which Carpenter, likewise, once regarded as orals, as true interradial plates. If the plates in *Haplocrinus* really were orals, and also the homologues of the six or more proximals of the Platycrinidæ and Actinocrinidæ, and of the five summit plates in *Stephanocrinus*, which all cover the peristomial area but not also the tentacular vestibule and the disk, it would follow that in the three latter the orals were carried inward by the calyx interradials by which they are surrounded, but not only, as perhaps might be the case in the Camarata, by their higher orders or upward growth, but even by the primary interradials. It would further suggest that in the earliest genera *Reteocrinus*, *Glyptocrinus* and allied forms, which have no proximals, the " orals " were unrepresented or resorbed. Also *Nanocrinus paradoxus* (Echin. Eifl. Kalk., Pl. 12, fig. 7 *i*) has no proximals, the covering pieces, according to our interpretation, rest directly against the central plate. This, we know, is the case in two undescribed species of *Talarocrinus*, which we discovered lately in Kentucky. In these species the central piece is relatively larger than the combined orals of *Stephanocrinus*, there are no proximals, and no other interradial plates touching the central plate. The covering pieces occupy here a similar position to the central plate—the coalesced orals—as in *Stephanocrinus* to the quinque-partite oral pyramid. There we have actual specimens, which in all essential points conform with the hypothetical Crinoid which we constructed.

From Carpenter's arguments (Chall. Rep., pp. 268–271) we conclude that he regards the hypothetical "orocentral" a kind of keystone, by which the actinal system is closed in a similar manner as at the opposite pole the dorsocentral is said to close the abactinal side. Unfortunately, however, this theory as stated, is not sustained by embryology. No such plate has ever been discovered among living Crinoids, not even in their larval state, before the opening of the tentacular vestibule, which is said to represent the condition of *Haplocrinus* morphologically. This difficulty Carpenter undertook to explain on p. 270 by stating, that if such a plate appeared " it would only be in the way, and have to undergo resorption to a greater or less extent." A weak argument considering that orals of recent Crinoids actually undergo that resorption. But, admitting it, what then became of the orocentral of *Stephanocrinus*, *Allagecrinus* and *Coccocrinus*, and what of the central piece in the oral pyramid of certain Cystidea? He states further "the former (basals) are within the ring of radials, and next to the dorsocentral; and it seems therefore only natural to regard the six proximal interradial plates surrounding the central piece (oro-central) in the vault of a Palæocrinoid as representing oral plates." This argument is not quite correct, in so far as the central piece is frequently surrounded not only by the proximals—his orals—but also by the radials and anal plate (see Pl. 7); contrary to the basals, which form a ring by themselves. Besides, his argument is based to a large extent, if not altogether, upon the hypothetical plate which he calls "oro-central."

Taking everything in consideration, is it not reasonable and more natural to regard the five orals of the Neocrinoidea, which in the larva are loosely folded together, and which in some of the Cystidea and also in *Stephanocrinus* were united by a close suture, as gradually becoming anchylosed in a group in which they were permanently closed, than it is to invoke the existence of a new element unknown in Echinoderm morphology, and even then have to assert that six plates take the place of five?! But not only that, we also have to admit that these so-called "orals" contain in their midst anal and radial plates contrary to the case of the orals of the Neocrinoidea, *Stephanocrinus* and the Cystidea, and contrary to the basals, the abactinal representatives of the orals as Carpenter admits.

As a further proof that the central piece is the representative of the orals, we refer to the Cystid genus *Caryocrinus*, which has three in place of five groups of arms, and which, according to our interpretation, has no proximals. The central piece which occupies the centre of figure, and which we think represents the oral pyramid, is surrounded by eight plates, by *five* (not four) large ones, and three smaller ones, the latter conforming jointly to one of the other five. Three of the plates have a strictly radial position, the three others, including the compound one which takes the azygous side, are interradial. We doubt if Carpenter will regard these six plates, wholly or partly, as the representatives of our proximals—his orals—or his theory will have to undergo further modifications, as he will find it difficult to restore five primitive pieces from an assemblage of plates as here exhibited.

STEPHANOCRINUS Conrad.

1842. Conrad, Journ. Acad. Nat. Sci. Phila., vol. 8, p. 278.
1851. Hall, Palæont. N. York, vol. ii, pp. 212 and 351.
1851. F. Roemer, Wiegmann's Archiv f. Naturgesch. Jahrg. xvi, vol. i, pp. 365-375.
1853. Joh. Müller, Verh. d. Berl. Acad. d. Wissensch., p. 211.
1855. Leth. Geogn. (Ausg. 3), p. 266.
1857. Pictét, Traité de Paléont., vol. iv, p. 304.
1862. Dujardin and Hupé, Hist. Natur. des Zooph., p. 266.
1879. Hall, 28th Rep. N. York St. Cab. Nat. Hist., p. 146.
1881. Hall, 11th Ann. Rep. of Indiana, p. 279.
1879. Zittel, Handb. d. Palæont. i, p. 436.
1883. Carpenter, Ann. and Mag. Nat. Hist., Apr., p. 237.

Stephanocrinus resembles in many respects certain forms of the Blastoidea, but has true brachial appendages. The calyx is subpyramidal, or deeply cup-shaped, with five spiniform interradial processes.

The basals form a large semicircular or subturbinate cup, more or less truncate at the bottom, with a trigonal distal face, which is slightly excavated for the reception of a column. They consist of three pieces, almost coequal as to size but not as to form, one of them being quadrangular, the two others pentangular. The quadrangular piece takes the position of the smaller basal in the Blastoidea, to the right of the anterior radial; contrary to other Palæocrinoidea in which it occupies the left side. In one specimen, however, exceptionally, it is placed posteriorly, supporting the greater half of two postero-lateral radials.

The first radials are large and resemble to a large extent the forked plates of certain species of *Codaster* and *Phænoschisma*, in which the limbs—the prongs of the fork—of two contiguous radials extend up between the arms in an almost vertical direction, but instead of forming, as there, a sort of pyramid, they are extended in *Stephanocrinus* frequently into long thornlike processes, which sometimes attain more than one-half the height of the calyx up to the arm bases. These processes form radially a deep gutter, containing the ambulacral groove which leads to the arms.

The second radials rest within a horseshoe-like depression near the outer end of the gutter. The plates are reniform, small, short, axillary, with three conspicuous prong-like projections extending inward. The outer ones of these projections are wing-like, resting against, and partly upon, the interradials; the inner one sword-shaped, their sharp point extended deeply into the ambulacral groove, so as to divide it, and to form a branch groove for each main division of the rays. *Stephanocrinus angulatus* evidently had ten arms to the ray, but the mode of branching beyond the second radials is not well known. We found, however, in one instance the second radial succeeded by two other axillaries. The arms are biserial, thin, short, pinnule-like, and they cover the whole ventral surface. In length they do not extend beyond the interradial processes, which apparently were to protect these delicate organs.

The interradials are comparatively large. They resemble in form and position the deltoids of *Codaster*, *Troostocrinus* and other Blastoids, in which, like here, no part of the plates is visible in a side view. They extend to the top of the projections and rest against the inner faces of two limbs, the suture running downwards so as to divide the processes into an inner and outer part. The plates are connected laterally with one another, but not centrally. They leave in the centre a moderately large open space, which in perfect specimens is filled by oral plates. The lateral edges of the interradials are deflected, curving downward, so as to form a wide and deep ambulacral groove, which on approaching the inner end becomes deeper and narrower, and toward the arm bases divides as stated above. The ambulacral grooves are readily distinguished from the general gutter formed by the protuberances. They contain neither hydrospires, nor pores, nor other openings, but there seem to be small axial canals at the arm bases. At each side of the ambulacral groove there is a sort of depression, which forms a place of attachment for two series of small, subquadrangular covering pieces, which form a vault over the groove, leaving underneath a circular, comparatively large passage, which at one end communicates with the arms, at the other enters the calyx beneath the edge of the oral pyramid. The covering plates of the same series are so closely anchylosed that they appear in the best specimens, even under a magnifier, as two single plates, one at each side, as which they were figured by Hall. Their composite nature and alternate arrangement, however, was ascertained in places where portions of this integument had been weathered.

The oral pyramid, which occupies the centre of figure, is placed on a level with the covering pieces to which it is closely attached. It rests against the truncated margins of the interradials, which for its reception are slightly excavated. It is composed of five subequal pieces, which are so closely united by suture laterally and centrally, that the suture lines are rarely visible, and the plates appear as if forming a single piece.

The anal aperture is located ventrally, near the top of one of the interradial processes, at the place where two of the limbs meet with the interradial. In its usual preservation it consists of a rather large circular opening, which, however, in perfect specimens is closed by a valve of from four to six small pieces.

The *Stephanocrinus* which Hall described and figured in the 28th Rep. of the N. York St. Cab. Nat. Hist. (Second Edition), p. 146, Pl. 14, figs. 15–20, is in our opinion specifically distinct from *S. gemmiformis,* and even generically unless the small interradial plates are very incorrectly outlined.

S. osgoodensis S. A. Miller (*Codaster osgoodensis*), Cincin. Journ. Nat. Hist., vol. ii, Pl. 10, figs. 7 and 7 *a*, which the author in his Catalogue of the Palæoz. Fossils (Second Edition) referred to *Stephanocrinus* is described from internal casts, and too incompletely known for identification. *St. pulchellus*, S. A. Miller, is a *Codaster.*

The column is small, and composed of comparatively long joints.

Geological Position, etc.—The genus has been found exclusively in the Niagara group of America.

The following species have been described :—

1842. **Stephanocrinus angulatus** Conrad. (Type of the genus). Journ. Acad. Nat. Sci. Phila., vol. viii, p. 279, Pl, 15, fig. 8.—Pictet, 1857, Traité de Paleont., vol. iv, Pl. 99, fig. 23.—F. Roemer, 1851, Wiegmann's Archiv., Jahrgang xvi, pp. 365–375, Pl. 5.—Hall, 1851, Palæont. N. York, vol. ii, pp. 213 and 351, Pl 48, fis. 1 *a–m,* and Pl. 85, figs. 1–4.—Niagara group. Lockport, N. York.

1851. **St. gemmiformis** Hall, Palæont. N. York, vol. ii, p. 215, Pl. 48, figs. 2 *a-i*; also 1879, 28th Rep. New York St. Cab. Nat. Hist., p. 146, Pl. 14, figs. 15–20; also, 1881, 11th Ann. Geol. Rep. Indiana by Collett, p. 279, Pl. 13, figs. 15–20,—Rochester, N. Y., and Waldron, Indiana (?).

NOTES ON THE UNDERBASALS AND TOP STEMJOINT OF NEOCRINOIDEA AND PALÆOCRINOIDEA.

On p. 8 we stated that probably many Neocrinoids, heretofore supposed to be monocyclic, either have small underbasals concealed beneath the column, or that these plates had been represented in the early larva. We referred to the genera *Pentacrinus*, *Millericrinus* and *Apiocrinus*, which, according to our generalizations on p. 7, are built decidedly on the plan of dicyclic Palæocrinoids. Our investigation, unfortunately, could be extended only to comparatively few species, as the column and axial canal of the Neocrinoidea very frequently, and even among the genera to which we alluded, are not angular, and *Pentacrinus* among the three is the only genus that has lateral cirrhi.

Rudimentary underbasals are known to exist in the Pentacrinoid genus *Extracrinus*, and similar plates have been discovered in the Apiocrinidæ by Mr. De Loriol in two species of *Millericrinus*. In these species, as in the case of *Extracrinus*, the angles of the column, when this is pentangular, are interradial, the canals radial, exactly as in species in which underbasals are supposed to be wanting, but contrary to the conditions of monocyclic Palæocrinoids in which the angles of the column are radial, the axial canals interradial.

Millericrinus polydactylus, according to Mr. De Loriol (Monograph of the French Crinoids, p. 553, Pl. 110, figs. 1 *a* and 2 *a*)[2], has five minute plates within the basal ring, which were regarded by him as "infrabasalia," the term which he applies to underbasals. De Loriol describes these plates as follows : "Je distingue très nettement, sur deux individus, cinq pièces extrêmement petites, à peine distinctes à l'œil nu, qui son logées au centre de l'article basal, chacune reposant sur le sommet de l'une des carènes, dans une direction radiale ; au centre se trouve une petite dépression qui forme le fond de la cavité. Ces petites pièces, que je n'avais jamais encore observées, jouent évidemment le rôle de pièces infrabasales, mais à l'état tout à fait rudimen-

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[1] By an error it was stated on p. 7 in Rule 2 : the five sections of the column are "*radial*," the longitudinal sutures "*inter*radial," which should read : the five sections of the column are "*inter*radial," the longitudinal sutures "radial."

[2] This and the succeeding quotations are made from the Paléontologie Française, 1re Serie, Animaux Invertébrés, Terrain Jurassique, Tome xi, Première Partie, Crinoides, par M. P. De Loriol, Paris, 1882–1884.

taire." Similar pièces were discovered by him in his *Millericrinus Orbignyi* (Pl. 116, figs. 1 *b*, *c*, *d*), upon which he says on p. 566: "Elles ne peuvent absolument se voir que lorsque, par un hasard heureux, l'article basal peut se dégager du calice. Il me paraît indubitable que ce sont là de petites pièces infrabasales rudimentaires semblables à celles que j'ai signalées dans le *Mill. polydactylus.*"

We fully agree with the distinguished Swiss palæontologist that the plates in question in both cases are rudimentary underbasals, from the very fact that the plates are disposed radially, the outer angles of the column interradially, as seen in *Mill. Orbignyi*, in which the stem is pentangular.

Admitting these plates to be underbasals, we doubt if all other species of *Millericrinus*, which have an interradial pentangular stem, and those with a round stem, and the species of *Apiocrinus*, a genus which, according to De Loriol, is closely allied to *Millericrinus*, should be devoid of underbasals. In that case the two species should be separated from the others, and be placed by themselves under a very distinct genus.

That small underbasals at least temporarily were represented in other species of *Millericrinus* and in *Apiocrinus*, is indicated by the fact that the open space within the basal ring, which in *Millericrinus Orbignyi* is occupied by the underbasals, is radial, contrary to the axial canals of monocyclic Palæocrinoids, which are interradial. Moreover, the space is not in proportion to the axial canal in the stem, which in both genera is small and circular. The space in these species is large enough to have contained, in addition to the axial canal, such small plates as De Loriol figured in *Millericrinus Orbigny*, and these, if present, would take the same position as the underbasals in that species.

In all dicyclic Crinoids, the column rests either exclusively against the underbasals, or, when these are very small, also partly against the basals. The latter is the case in the two species of *Millericrinus* where underbasals are known to be present. In these species they form together with the basals a deep concavity for the reception of the top stem joint, which occupies the whole concavity, as beautifully shown by De Loriol in *Mill. polydactylus* (Pl. 110, fig. 1 *a*). In other species of *Millericrinus* in which no underbasals have been observed, and in the genus *Apiocrinus*, the structure is fundamentally the same, except that the columnar concavity is formed exclusively by the basals, the underbasals being here absent, and the space which they should fill left vacant in the fossil. In all these species the top stem joint occupies the same position toward the basals that it does in the two species in which the underbasals are in place, although the plate varies considerably in form. In some of them it appears as if forming a part of the calyx, in others as an ordinary stem joint. In some species it is much wider than the succeeding joints, in others of the same width; but there are all possible gradations between the extremes. In all of them, however, the plate rests against the outer walls of the basals as in *Mill. polydactylus*, not within the basal ring, and in all of them the basal concavity, whether large or small, is completely filled by the top stem joint.

It is very interesting that in the two cases in which De Loriol accidentally discovered underbasals, these were separated from the basals, and are closely attached to the column, which goes to prove that probably already a partial resorption of the plates took place. It suggests further that the union with the underbasals was tighter than with the basals, that probably the former was effected by common suture, the other by syzygy or some other loose way, the apposed faces being either striated or showing traces of fossæ.

A near approach to the structure of *Millericrinus polydactylus* we find in *Mill. Piletti* (Pl. 63), in which no underbasals were observed, but the lateral faces of the basals (fig. 8 *a*) show clearly that underbasals were once present. The column also here, from the first joint down, is strictly interradial, the axial canal small and round, and not in proportion to the large open space between the basals. The basal concavity is funnel-shaped, very deep, wide at the outer end. The upper stem joint is large, and extends in width considerably beyond all succeeding joints.

A similar base exists in *Mill. Milleri* (Pl. 96), in which again the upper columnar joint is laterally extended and strictly interradial, the columnar canal round, and much smaller than the open space within the basal ring, which is star-shaped, the rays directed radially.

A very different base is figured by De Loriol in *Apiocrinus magnificus* (Pts. 46–48), in which the top stem joint takes the form of the anchylosed underbasal disk of the Palæocrinoid genus *Stemmatocrinus*. A comparison, however, with other species proves very clearly, that it is a top stem joint of a very extreme form, and that the plate actually rests *against the outer faces* of the basals, and not *between* the basals as in the case of the inner plate in *Stemmatocrinus* and *Cupressocrinus*, which Carpenter (Chall. Rep., p. 152), as we think, erroneously took to be a stem joint. The plate in *Apiocrinus magnificus* is not, as should be supposed from appearances, disposed radially, but interradially, as shown by comparison with species having a pentangular stem. It attained its radial angles accidentally by adapting its form to the basal concavity which is naturally angular. The case is parallel to that of *Eucalyptocrinus* and *Barrandeocrinus*, in which the angles of the upper column are shaped so as to conform with surrounding plates, which are in that genus the radials.

In *Apiocrinus Parkinsoni* (Pts. 27 and 28) and in *A. roissyanus* (Pts. 41–45), the basal structure is similar to that of *Ichthyocrinus*, but, while in the latter the underbasals are persistent through life, they may have disappeared in the other. The basal concavity is shallow, and in both species the upper portions of the column taper abruptly in a downward direction. The same is the case frequently among the Ichthyocrinidæ.

The base of *Guettardicrinus* and *Rhizocrinus* is in a similar condition, but less concave. For *Rhizocrinus* we refer to the Challenger Report, Pl. x, figs. 5 and 9. The top stem joint resembles closely that of *Apiocrinus*, and also the basal concavity, which also here is filled completely by the top joint. The columnar canal is circular or ovoid, and much smaller than the pentangular space within the basal ring, which, contrary to monocyclic Crinoids, is directed radially. The same is the case in *Guettardicrinus*. Both genera are built on the same plan as *Apiocrinus*, and if the latter possessed underbasals, these plates were also present in *Rhizocrinus* and *Guettardicrinus*.

In the Pentracrinidæ, and not only in *Extracrinus*, in which underbasals have been observed, but also in *Pentracrinus* and *Metacrinus* in which they are said to be absent, the angles of the column, without exception, are interradial, the lateral cirrhi radial, but, while the axial canals of *Metacrinus*, and probably *Extracrinus*, are radial [1] in conformity with dicyclic Palæocrinoids, they are interradial in *Pentacrinus*,[2] as in all monocy-

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[1] Challenger Report, Pl. 12, figs. 1 and 2, and Pl. 41, figs. 6 and 7.

[2] Pl. 12, figs. 15 and 16 ; Pl. 20, figs. 1 and 2 ; Pl. 22, figs. 1, 2, 7 ; Pl. 23, figs. 1 and 2 ; Pl. 26, fig. 11 ; Pl. 27, figs. 2, 3 ; Pl. 30, fig. 4 ; Pl. 34, figs. 8 and 9 ; Pl. 37, figs. 14 and 15.

clic older Crinoids. This departure from what we discovered to be the rule in the Palæocrinoidea induced us not to mention the axial canals in suggesting on p. 71 that perhaps " all Neocrinoids, or at least many of them, may have possessed in their larval state rudimentary underbasals hidden by the column," basing our arguments mainly upon the interradial angles of the column and the radial position of the columnar cirrhi. This forms at present an objection to our view that the two genera, and especially *Pentacrinus*, are dicyclic. On the other hand it must not be overlooked that the position of the column, whether radial or interradial, apparently is governed by laws similar to those by which the underbasals are radial, the basals interradial. The pentapartite stem—and this is found in quite a number of palæozoic genera, especially Silurian—alternates always with the proximal ring of plates, the segments are radial when there are basals only, interradial when also underbasals are present. In Palæocrinoids in which the column is undivided and pentangular, its position, whether radial or interradial, is ascertained from its lateral angles, and hence their direction morphologically important. In species in which the underbasals are small, and completely covered by the column, as sometimes in *Barycrinus*, the angles of the column occupy the same relative position toward the basals, as the upper stem joint of *Metacrinus*, *Pentacrinus*, *Millericrinus* and the centrodorsal of all Comatulæ does toward their basals. This led us to the conclusion that either the rules, which meet with no exception among Palæocrinoidea, as far as we know, either do not hold good for the Neocrinoidea, or the genera to which we alluded, and which are built otherwise upon the plan of dicyclic Crinoids, really possessed rudimentary underbasals during life as *Extracrinus* and certain species of *Millericrinus*, or that perhaps underbasals were present in their larva.

The ventral surface of the centrodorsal in some species of *Antedon* is almost identical with that of the top stem joint of *Millericrinus*, the plate is also interradial (Pl. 6, fig. 11), and rests, as in the Apiocrinidæ, against the outer face of the basals, not within the basal ring. It is similar in other Comatulæ, in all of which the centrodorsal is interradial, and upon this mainly, we base the opinion that perhaps also the Comatulæ in their early larva had rudimentary underbasals. That these plates, if present, were not observed, is not surprising, as they may have been very minute and been covered entirely by the column.

Zittel suggested (Handb. d. Palæont., i, p. 390), that the plate which connects with the basals in *Apiocrinus* probably represented an anchylosed underbasal disk, composed of five pieces. That this is impossible is shown by the case of *Mill. polydactylus*, which in that case would have two rings of underbasals. We fully agree with De Loriol and Carpenter that it is an enlarged stem joint, and believe that the plate represents morphologically the top joint (the first one beneath the basals) of all Crinoids, recent or fossil. The plate forms no integral part of the calyx, but rests in all cases either against the dorsal (outer) face of the basals, against the underbasals, or against both of them. It is disposed interradially in the Apiocrinidæ, Pentacrinidæ and Comatulæ, similar to dicyclic Palæocrinoids, and undivided; while in other groups it is sometimes compound (tripartite or quinquepartite). The underbasals, however, form an integral part of the calyx, they rest within the basal ring, against the lateral faces of the plates, and they are composed primarily of five pieces, which occasionally are reduced by anchylosis to three, or coalesced into a solid disk. If this is correct, it follows that the inner plate of *Stemmatocrinus*, *Cupressocrinus* and allied genera is not a stem joint, as suggested by Carpenter (Chall. Rep. 153) and others, but an anchylosed underbasal disk, as seen by examining the inner side of the calyx, which shows that the plate forms a part of the calyx, and rests against the lateral faces of the basals, within the basal ring, and not against their outer faces.

ADDITIONS AND CORRECTIONS.

Owing to peculiar circumstances preventing a sufficiently careful supervision of publication (although the proofs were carefully examined by one of the authors), a number of errors have been detected, especially in the first section of Pt. III. Two or three of these are exceedingly annoying, entirely changing our meaning. We request our readers to make the changes at once in their copies as indicated below.

PART I.

On p. 239 (Ex. Ed., p. 16), 6th line from bottom, for "Palæocrinoids" read "*Pentacrinoids.*"

On p. 251 (Ex. Ed., p. 28), 16th line from top, for "first radials" read "*basals*" (although the interpretation thus indicated has been modified by us).

On p. 324 (Ex. Ed., p. 101), 11th and 10th line from bottom, change twice: "radial" into "*interradial,*" and "interradial" into "*radial.*"

Part II.

On p. 207 (Ex. Ed., p. 33), 4th line from bottom, for "inverted" read "*recumbent.*"

On p. 247 (Ex. Ed., p. 73), 19th line from bottom, for "ornigranules" read "*ornigranulus.*"

On p. 250 (Ex. Ed., p. 76), 4th line from top, for "vesiculus" read "*vesiculosus.*"

On p. 281 (Ex. Ed., p. 107), 20th line from top, for "elongatulus" read "*elegantulus.*"

On p. 281 (Ex. Ed., p. 107), 16th line from top, for "comptus" read "*comtus*;" and 20th line from bottom, for "Harbrocrinus" read "*Habrocrinus.*"

On p. 298 (Ex. Ed., p. 124), 2d line from top, for "posterior" read "*superior.*"

On p. 299 (Ex. Ed., p. 125), 7th line from top, for "first" read "*second.*"

On p. 319 (Ex. Ed., p. 145), 2d line from bottom, for "tennuis" read "*tenuis.*"

On p. 320 (Ex. Ed., p. 146), 1st line from top, for "tennuisculptus" read "*tenuisculptus.*"

On p. 356 (Ex. Ed., p. 182), 12th line from top, for "basals" read "*underbasals.*"

On p. 389 (Ex. Ed., p. 215), 4th and 11th lines from top, for "pendant" read "*pendent.*"

On p. 393 (Ex. Ed., p. 219), 14th line from top, for "mammilaris" read "*mammillaris.*"

Part III, Sect. I.

On p. 228 (Ex. Ed., p. 6), top line, insert after "and" the words "*we think.*"

On p. 229 (Ex. Ed., p. 7), 5th line from bottom, for "radials" read "*interradials,*" and 4th line from bottom, for "interradials" read "*radials.*"

On p. 230 (Ex. Ed., p. 8), 15th line from top, after the word "cirrhi" insert "*when present.*"

On p. 232 (Ex. Ed., p. 10), 10th and 11th lines from top, for "postero-lateral" read "*antero-lateral.*"

On p. 235 (Ex. Ed., p. 13), 8th and 10th lines from top, for "Pl. 6" read "*Pl. 5;*" also 4th line from bottom, for "Hoplocrinus" read "*Haplocrinus.*"

On p. 241 (Ex. Ed., p. 19): Our statement in the 16th and 17th lines from bottom has been made the basis of a criticism by Dr. P. H. Carpenter, which is well founded. It did not properly express our meaning, and we change it as follows: Strike out all after the word "present" to the end of the sentence, and insert: "*in others apparently absent externally, either as a rule or occasionally, but in these cases we believe them to be represented on the ventral side, as in the Crotalocrinidæ.*" In the same connection, on p. 295 (Ex. Ed., p. 73), in the 12th line from the top, strike out "*all,*" and after the word "are" insert "*generally.*"

On p. 245 (Ex. Ed., p. 23), 3d line from top, for "Palæocrinidæ" read "*Palæocrinoidea.*"

On p. 249 (Ex. Ed., p. 27), 6th line from bottom of text, for "Pl. 2" read "*Pl. 5.*"

On p. 253 (Ex. Ed., p. 31), 8th line from top, for "stellatus" read "*stellaris.*"

On p. 254 (Ex. Ed., p. 32), 18th line from top, before "alone" insert "*perhaps.*"

On p. 255 (Ex. Ed., p. 33), 14th line from bottom, for "multiradiatus" read "*multibrachiatus,*" and for "fig. 2" read "fig. 6;" also 11th line from bottom for "Norwordi" read "*Norwoodii;*" also 5th line from bottom, for "to each plate" read "*or more.*"

On p. 263 (Ex. Ed., p. 41), 5th line from bottom, for "radials" read "*interradials.*"

On p. 277 (Ex. Ed., p. 55), 14th line from bottom, for "Pl. 8" read "*Pl. 9.*"

On p. 285 (Ex. Ed., p. 63), 9th line from top, for "Pl. 1" read "*Pl. 4.*"

On p. 287 (Ex. Ed., p. 65), 5th line from bottom, for "Iovensis" read "*iowensis.*"

On p. 291 (Ex. Ed., p. 69), 12th line from top, for "anal" read "*oral.*"

On p. 292 (Ex. Ed., p. 70), 14th line from top, read "*Palæocrinoidea.*"

On. p. 294 (Ex. Ed., p. 72), last line, for "as a rule" read "*always.*"

On p. 295 (Ex. Ed., p. 73), top line, for "Palæozic" read "*Palæozoic.*"

On p. 3 0 (Ex. Ed., p. 78), at top, for "Stellerites" read "*Stellerids.*"

On p. 303 (Ex. Ed., p. 81), 16th line from bottom, for "Palæocrinoidæ" read "*Palæocrinoidea.*"

On p. 307 (Ed. Ed., p. 85), 15th line from top, for "Beteocrinus" read "*Reteocrinus.*"

On p. 312 (Ex. Ed., p. 90), 6th line from bottom, for "Platynicridæ" read "*Platycrinidæ.*"

On p. 321 (Ex. Ed., p. 99), under Thylacocrinus, for "Vanniosti" read "*Vannioti.*"

On p. 327 (Ex. Ed., p. 105), top line, for "mespiliformes" read "*mespiliformis.*"

On p. 336 (Ex. Ed., p. 114), 12th line from bottom, for "simple" read "*single.*"

On p. 349 (Ex. Ed., p. 127), 18th line from bottom, for "Nebergangsgeb.," read "*Uebergangsgeb.;*" and on the 11th line, for "Dupé" read "*Hupé.*"

On p. 359 (Ex. Ed., p. 137), 9th line from top, for "peristomeal' read "*peristomial;*" and 12th line, for "were" read "*was.*"

Mr. W. R. Billings discovered underbasals in *Glyptocrinus priscus*, and we therefore refer the species to "*Ptychocrinus.*" He also did send a diagram of *Rhodocrinus* (?) *asperatus*, which leaves but little doubt that it is a somewhat aberrant form of "*Archæocrinus.*"

PART III, SECT. II.

On p. 71 (Ex. Ed., p. 147), 13th line from bottom, strike out the word "*constructed.*"

On p. 79 (Ex. Ed., p. 155), 2d line from bottom, read "*Myrtillocrinus*" without an "*h.*"

On p. 89 (Ex. Ed., p. 165), 10th line from top, for "Austini" read "*Austinii.*"

On p. 90 (Ex. Ed., p. 166), 3d line from bottom, for "Scytalocrinus" read "*Stylocrinus.*"

On p. 99 (Ex. Ed., p. 175), 11th line from top, for "T. granulatus" read "*T. pyriformis.*"

On p. 105 (Ex. Ed., p. 181), 14th line from bottom, for "pyrimidalis" read "*pyramidalis.*"

On p. 115 (Ex. Ed., p. 191), 15th line from top, for "Streblocrinus" read "*Streptocrinus.*"

On p. 150 (Ex. Ed., p. 228), 22d line from top, for "subuminus" read "*subtumidus.*"

On p. 157 (Ex. Ed., p. 233), 18th line from top, strike out the brackets and insert "commas" in their place.

On p. 161 (Ex. Ed., p. 237), 5th line from bottom, for "Dactilocrinus" read "*Dactylocrinus.*"

On p. 162 (Ex. Ed., p. 238), 13th line from top, for "single" read "*simple.*"

On p. 163 (Ex. Ed., p. 239), 16th line from bottom, for "Parisocrinus" read "*Pachylocrinus.*"

On p. 166 (Ex. Ed., p. 242), 11th line from bottom, insert: "**Woodocrinus coxanus, Worthen (Zeacrinus coxanus), Geol. Rep. Illinois, vii, p. 302, Pl. 28, fig. 1. Keokuk gr.—Hamilton, Ill. Syn. Zeacrinus Keokuk, ibid., p. 303, fig. 3.*"

On p. 167 (Ex. Ed., p. 243), 10th line from bottom, for "Pl. 6, fig. 3," read "*Pl. 6, fig. 9 and Pl. 9, fig. 8.*"

On page 169 (Ex. Ed., p. 245), 5th line from bottom, for "orbicularis" read "*globularis.*"

On p. 171 (Ex. Ed., p. 247), 12th line from bottom, for "Epachycrinus" read "*Eupachycrinus.*"

On p. 173 (Ex. Ed., p. 249), 17th line from bottom, for "platybasilis" read "*platybasalis.*"

On p. 175 (Ex. Ed., p. 251), 15th line from top, add the word "*right*" before postero-lateral.

On 177 (Ex. Ed., p. 253), 18th line from bottom, for "Eriocrinus" read "*Erisocrinus.*"

On p. 197 (Ex. Ed., p. 273), 21st line from top, leave out the word "*axial*" before "canal."